SATELLITE SCANNED DATA IN THE FUNCTION OF VEGETATION MAPPING

SATELITSKO SKENIRANI PODATKI ZA KARTIRANJE VEGETACIJE

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POVZETEK

Kartiranje vegetacije ima pri nas dolgo tradicijo. Za območje Slovenije obstajajo za zadnjih 250 let karte različnih meril in tematik, s katerih lahko razberemo položaj in obseg posameznih vegetacijskih tipov. Teh virov (vojaških in katastrskih kart) smo se poslužili pri rekonstrukciji razvoja in sprememb zemljiških kategorij in vegetacijskih tipov na Apaškem polju, poleg tega pa obravnavali tudi spremljajoče statistične podatke. Dobljene podatke smo nato primerjali s podatki kartiranj vegetacije zadnjih štiridesetih let ter z najnovejšimi statističnimi podatki.
Terensko kartiranje vegetacije je zahtevno, zamudno ter drago opravilo, kjer igra veliko vlogo usposobljenost raziskovalcev. Da pa bi zmanjšali vpliv subjektivne ocene ter zmanjšali čas in stroške pridobivanja podatkov, smo v ta proces vključili daljinsko zaznavanje. Uporabnost te metode za kartiranje vegetacije smo preizkusili na območju Apaškega polja in okolice, dobri rezultati pa predstavljajo osnovo za prihodnje raziskave.
Prikazana je tudi uporaba satelitsko skeniranih podatkov za kartiranje vegetacije in za izdelavo GIS-ov s poudarkom na skeniranih podatkih satelitov Landsat-TM in SPOT-PAN. Opisana je mono in multitemporalna analiza vegetacijskega pokrova Slovenije, pri časovni analizi pa je prikazan vpliv datuma skeniranja na skenirane vrednosti odbitega elektromagnetnega valovanja. Obravnavane so omejitve za možno operativno uporabo satelitsko skeniranih podatkov, kakor tudi uporaba obstoječih statističnih metod za statistično oceno kakovosti prostorsko razporejenih podatkov.

Ključne besede: daljinsko zaznavanje, groba klasifikacija, kartiranje vegetacije, mehka klasifikacija, Slovenija, zemljiške kategorije, satelitski podatki, pokrovnost tal, raba tal, GIS, časovna analiza, ocena kakovosti

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ABSTRACT

The vegetation mapping has had a long tradition in Slovenia. For this territory there are several types of cartographic material presenting the land use in various temporal and geographical scales. To reconstruct the development of changes in land use or in vegetation, we consider historical maps (old military and cadastral maps) and also statistic numerical data. Since 1962 the project Vegetation mapping of Slovenia has been carried out and now the whole area is mapped mostly in scale 1:50.000. From the beginning of vegetation mapping 36 years ago, there are already quite big changes in areal extension and in classes of vegetation.

In view to reduce the time and costs of re-mapping on classical way, the introduction of the new technology (satellite images, GIS) of vegetation mapping was initiated. That enables to take in consideration the whole large areas and to show the situation of vegetation in one moment. As an object of investigation the areas covered with forest in NE part of Slovenia were used, because this is, in view of the quality and quantity, the most stabile land use category. The results of that research should help to produce the procedure for elaboration of satellite images and thus help to vegetation mapping.

An overview of the use of satellite scanned data for vegetation mapping and for the compilation of various GISes is given with the emphasis on the data obtained by Landsat-TM and SPOT-PAN satellites. Mono and multitemporal analysis of the vegetation cover is described and the effect of acquisition date on scanned reflectance values demonstrated. Constrains for an operational use of the existing satellite scanned data are discussed as well as the use of existing statistical methods for quality assessment of the spatial distributed data.

Keywords: Hard classification, Land use, Remote sensing, Slovenia, Soft classification, Vegetation mapping, Satellite data, Land Cover/Use GIS, Multitemporal analysis, Quality control

In contribution some approaches to vegetation mapping, according to various techniques depending of specific type and origin of data, are presented. It's important to know the purpose and especially the expectations of investigation before we start with work, because of that depend the selecting and usage of input data and the methods of research. The best way for presentation is to show it on a specific example.

The aim of the one part of the project was to reconstruct the changes in land use over the last 230 years on the basis of old maps and statistical data. The next step was a comparison with the recent vegetation situation, derived from recent vegetation maps and with usage of satellite images and GIS operations.

The area of interest was Apaško Polje field (46°40' - 46°43' N; 15°47' - 16°00' E) which is situated in northeastern Slovenia in the transitional zone between the subalpine and subpannonian regions.

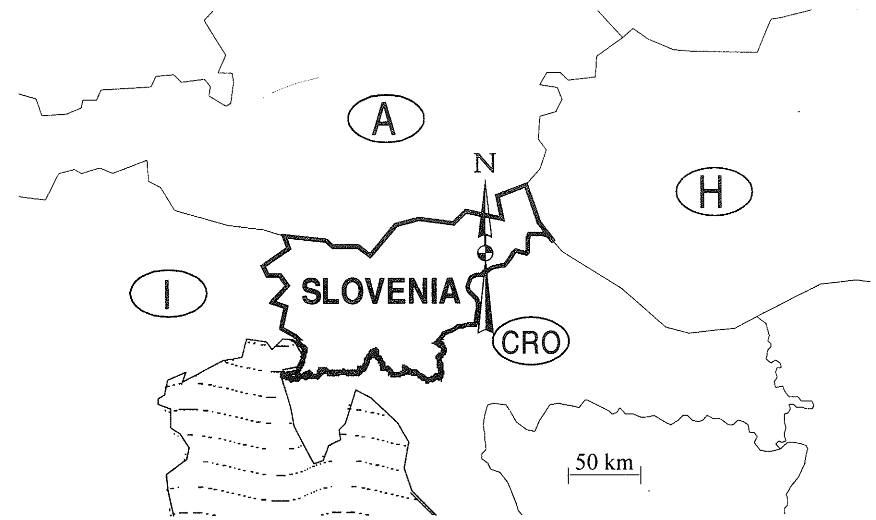

Figure 1: The position of Slovenia and Apaško polje field (arrow centre).

There are several types of cartographic material on Slovenia presenting land use in various temporal and geographical scales (Krušič 1996). The oldest map is a military map from the mid 18th century. It is very superficial and can hardly be used for the purpose of vegetation analysis. Later, with the introduction of taxes in the early 19th century, more sophisticated cadastral maps were prepared. To chart the changes in vegetation over the last 230 years, military maps from the 18th century, cadastral maps from the 19th century, numerical data from 1900, and current cadastral statistical data were used.

The military maps were made between 1763 and 1787 exclusively for military purposes and were part of the Emperor Joseph II Land Survey (Rajšp et al. 1996). In that period, most of present-day Slovenia belonged to the Austrian Empire. The maps were drawn to a scale of approximately 1:28.800, and distances were measured in hours and footsteps (Rajšp et al. 1996). They are not sufficiently accurate to be processed by the GIS. Nevertheless, they are useful because in addition to other objects of military importance, fields, pastures, and forests were mapped. The positions and areas of the land use categories were considered and transferred to our topographic maps by interpolation.

The next step was to study and process the cadastral maps made between 1819 and 1823 for the Economic Cadastral Survey for Regulation of Land Taxes ordered by Austrian Emperor Franz I. The maps were made primarily for taxation purposes and were very precise in positions, measurements, and descriptions of the land use categories. To transpose the maps, a mathematical and graphical trigonometric net was used to redraw every cadastral unit on a separate sheet on a scale of 1:2.880 in Cassini cartographic projection (Triglav 1996). The transfer of the positions and areas of the land use categories was also made by interpolation because the originals, which are kept in the Archive of the Republic of Slovenia, are in bad condition.

Data on areas of different types of land use from 1900 (Anon. 1904) obtained from the inventory of cadastral measures from 1824 and 1864 and numerical data on current land use are also included.

After the consideration of historical data about vegetation on Apaško polje field the conclusion was that the areas of specific categories haven't change for more than a few percent in comparison with nowadays situation.

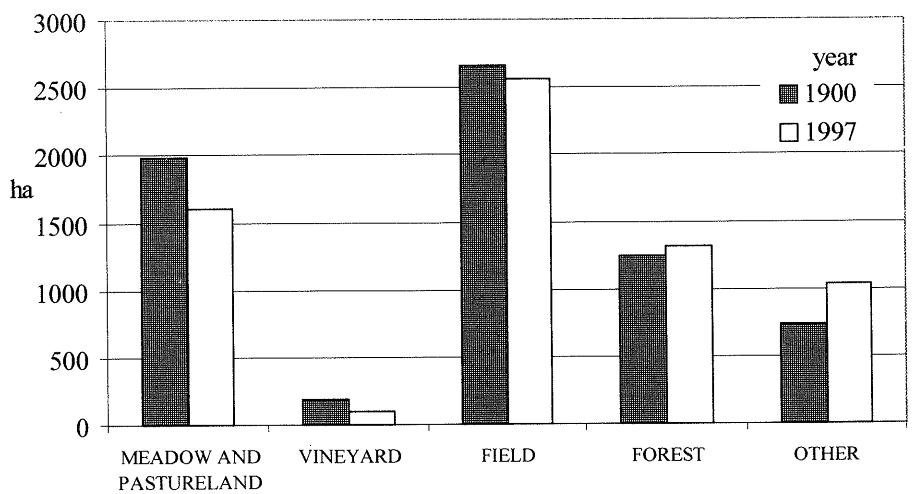

Figure 2: Land use categories according to historical maps and statistical data.

The vegetation mapping has a long tradition in Slovenia. However in our institution we haven't work with chronological or periodical observations of vegetation, but mostly with situation at present moment. There is no permanent stations or points where this researches would be made. In past 36 years the project Vegetation mapping of Slovenia has been carried out and now the whole area is mapped mostly in scale 1:50.000. Yet, most of the maps remain in manuscript form.

There is a few possibilities to perform field mapping and can be declared as so called classical approach. Field mapping depend on type of vegetation and map scales. They also demand previous room preparation (consideration of aero photographs, topographic maps, already existing vegetation maps, intersectal diagrams). For field observations there is a need for well trained observers with a lot of experience. In

many places, the situation of vegetation can be changed in both ways, quantitatively and qualitatively. For recognition of those changes, we could start to remap all parts of country, but in the end of that process, while this procedure of mapping on classical way is so long terming, we could start again.

The results depend on personal judgement, and therefore the possibility of mistake always exist. To avoid or reduce the possibility of subjective estimation, and to reduce the time and costs of field inspections, we introduced teledetection (in co-operation with Spatial Information Centre from Centre of Scientific Research of the Slovenian Academics of Sciences and Arts) in our researches. That enables to take in consideration the whole large areas and to show the situation of vegetation in one moment.
The main idea was to examine the applicability of remote sensed data for our needs.
The research began with unsupervised image classification, since we wanted to show the capabilities of Landsat TM data and remote sensing in vegetation studies (Landsat TM, channels 3, 5, 7 infra red spectre, with 30x30m resolution). After unsupervised classification the objects were divided into 6, 10 and 14 categories. The results were compared with vegetation maps, aero photographs and field observations to divide forests as an object of investigation from other categories.

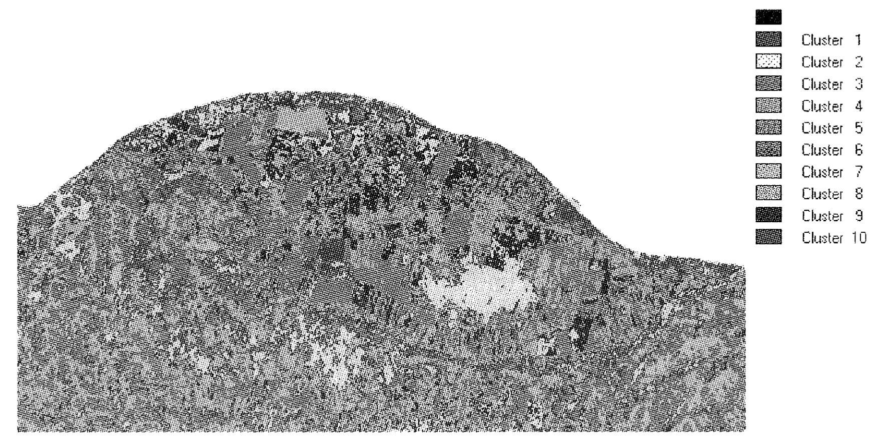

Figure 3: Field objects after unsupervised classification divided into 10 categories.

After some preliminary results, supervised classification was used. The image was georeferenced, preprocessed, and classified using Erdas Imagine (Erdas, Inc.). In the final step, the results were transferred into ArcInfo and ArcView databases (ESRI, Inc., Redlands, California, USA) to produce maps and compare them with other data. The remote sensing produced a map that correlates quite well with the map produced by field mapping. We also found the changes in category of forest in the SE of area observed. After another field inspection we found, that previous *Castaneo-Fagetum* forest was cut and the *Quercus robur* dominated forest is located on the lower part of the slope and there is also an ash plantation on the slope.

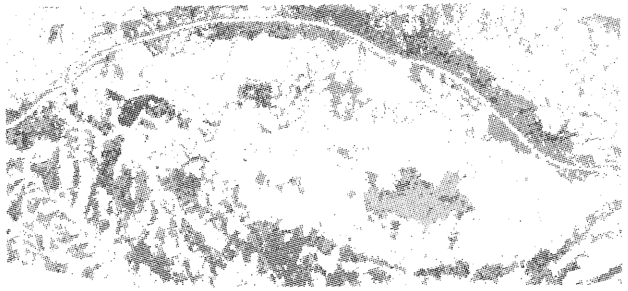

Figure 4: Forest types according to the supervised classification of the remotely sensed image based on several field inspections.

The usage of teledetection in vegetation mapping proved to be very useful. Our next task is to develop the "key", with other words to determine the process of getting information about the vegetation types in geographically similar areas, which are larger, distant, or difficult for field observation, on the base of results derived from a genuine test areas. We suppose to be able to predict and determine the vegetation with high accuracy from combination of remote "key" and digital model of relief, digital pedological data, radar images and advanced classification techniques.

1 COMPILATION OF THE LAND COVER GIS OF SLOVENIA - 1993 FROM SATELLITE SCANED DATA

For the needs of agricultural statistics, national agricultural policy, land use planning and monitoring environmental changes a uniformly produced digital land-cover map of Slovenia has been compiled on the Department of Statistical Geomatics and GIS of the Statistical Office of RS in 1995 from Landsat-TM/93 satellite scanned data by stratification process with the minimal mapping unit of 20 hectares. This first choropleth digital land cover map of Slovenia confirmed the long suspected but never estimated high increase of the areas under forest and built-up areas on the account of agricultural land.

In 1996 it was decided to improve the content of the existing land cover map of Slovenia by the compilation of a Statistical Land Cover/Use GIS of Slovenia on the Regional level for state 1993. First, the nomenclature was elaborated. No satisfactory nomenclature that would clearly separate land cover categories from land use classes using only Landsat-TM data has been defined, since the Landsat-TM satellite scanned data give information only on reflected values of the land cover and no information on whatever use of the feature whose reflectance value is captured within the 30 m x 30 m pixel(s): wooded land cover, agriculture land use, water land cover, bare rocks as land cover, built-up as land cover (within that land use of areas under houses with yards,

areas under roads and under railways with railway stations, areas of recreation under vegetation and masks of larger built up places) and category other, comprising land dumping grounds, gravel pits, quarries, etc. The descriptions of defined land cover categories and land use classes are published in: Rapid Reports No. 42/98.

As the base map the georeferenced mosaic of Slovenia, compiled from a set of Landsat-TM/93 data was used. These data were the only reliable source of the state of land cover in 1993 uniformly covering the whole area of Slovenia. The georeferenced mosaic with the RMS < 30 m was produced on the Statistical Office of RS. In addition official georeferenced databases that would help to determine the land cover categories and land use classes as: digitised boundaries of forest, draft version of digitised boundaries of water, centroids of houses, vectors of roads and railways and data from the register of digital administrative boundaries were used. A more detailed description of these data as well as the results of the compiled GIS are given in Rapid Reports no 42/98.

2 UPDATING THE LAND COVER GIS OF SLOVENIA TO STATE 1997

The first objective of the follow up project is to update the existing Land Cover GIS of Slovenia from the state in 1993 to the state in 1997. In addition to the updated georeferenced databases used in the compilation of the Land Cover GIS of Slovenia-state'93 the following sets of raster data are used:
- set of Landsat-TM/97 data;
- orthorectified Spot-Pan/96-97 data, given to our disposal from the Ministry of Defence;
- vector data of locations of dumping grounds, gravel pits and quarries.

Areas covering the Spot-Pan/96-97 rectified images are being cut from Landsat-TM/97 and Landsat-TM/93 mosaic, resampled to pixel size of 10 m and georeferenced to the Spot-Pan/96-97 scenes with RMS < 10 m. The first two visible bands of Landsat-TM/97 were replaced by Spot-Pan/96-97 band.

To obtain a better discrimination between bare dry soil and built-up areas two filters were applied over Spot-Pan/96-97 data:
- the summary 5x5 filter that increases the contrast along object edges and results in a multimodal distribution of reflectance values with an increased standard deviation;
- the 3x3 edge filter applied over original Spot-Pan/96-97 data to discriminate high reflectance built-up areas from all other features.

The resulting image produced from these three bands, resembles a pseudo-colour composite and enables a significant better visual discrimination between built-up areas and bare dry soil, undiminished discrimination of other categories and an improves the discrimination of grassland and clear-cuts within forest areas.

3 ESTIMATION OF LAND COVER CHANGES

The second goal is to estimate the land cover changes in the period 1993:1997. The two sets of Landsat-TM data with acquisition dates early summer 1993 and spring 1997 are in the process to be analysed.

The image to image georeferencing is performed. In order to avoid misregistration TM/97 scenes are referenced to the georeferenced TM/93 mosaic with RMS less than 1/2 pixel accuracy.

In order to target possible locations of land cover change in the time span 1993:97 TM bands 6, 7 and 2 from both years are being classified separately. In spite of the fact that the TM band 6 has a more coarse pixel of 120m x 120m it is expected to be useful since areas having hotter sun-facing slopes will be more outstanding and the valley regions in hilly and mountainous areas better determined. The boundary between the forested areas and the areas being under shadow is expected to be better visible in the early spring date of 97-TM data compared to the summer date of TM-93 data. Thus, the difference between the shadows in the valleys that would be predominately classified into forested areas will be reduced to a minimum. Areas that have not been under vegetation on both scanning dates will have on both images brighter values in band 6 due to the absorbed solar radiation thus emitting thermal energy.

For a more detailed classification, TM bands 4, 5 and 7 are being used. As the scenes from both years are haze free, TM bands 3 will be included. It is assumed that the use of these bands will offer the highest within vegetation separability and will be therefore used for the classification *(Fig.5)*. The separate classification of scenes instead of the mosaic as a whole will eliminate the difference in scanning dates of the scenes and though contribute to a better interpretability of obtained clusters.

The updating has been till now finished over one statistical region where in addition quality assessment of the obtained results has been performed using the error matrix method on two segments, each of size 900 hectares. The overall accuracy of the compiled GIS-'97 is higher than 90%, the agriculture land use is estimated with an accuracy higher than 90% and the wooded land cover with an accuracy between 73% - 94 %.

It was expected that the most dynamic land cover changes did take place in the built-up category. We did not expect to be able to classify individual houses with these satellite data. Since it was our attempt not only to identify the extend of the change in the built-up category but also to estimate how much of the built-up area did expand in the

analysed time on the account of other land cover categories buffered centroids from year 1993 were subtracted from buffered centroids from year 1997. The average rate of new built-up hectares per year was calculated. The identification of the underlying land cover category showed that 855 hectares of agriculture land changed to built-up land cover and only 41 hectares of forest has changed to built-up land cover. The distribution of augmented built-up areas within each statistical region over various land cover categories is reported in Rapid Reports No 121.

Figure 5: Example of detected land cover change in the period from 1993 to 1997 over an area in updated Land Cover GIS of Slovenia (Gauss-Krüger co-ordinates of the UL corner: X/Y= 5606000/5162000) where **gray colour (arrow pointed) indicates the extent of the changed wooded land cover to agriculture land use.**

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