**REVIEW**
by

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*Subject: Procedure for obtaining a doctoral degree with a dissertation topic “Mapping of Natura 2000 protected areas using remote sensing and GIS” in the professional field 4.4 Earth Sciences, specialty: Cartography and GIS.*

The thesis entitled “Mapping of Natura 2000 Protected Areas Using Remote Sensing and GIS” presented by Stefan Genchev is structured in four chapters with individually separated introduction, conclusion and literature in a volume of 159 pages, 36 figures and 9 tables, cited 87 literature sources and 23 websites.

The relevance of the study has paid attention to the importance of mapping the sites protected in NATURA 2000 in order to better protect, manage and preserve them. It may have been possible to avoid the information related to some legal characteristics and projects for the development of the NATURA zones, and to put a clearer emphasis on the specific specifics of the scientific study.

The object of study is focused on land cover and land use, with the selection of two model areas of Natura 2000 protected areas - Dragoman and Rayanovtsi.

The subject is aimed at mapping the state of land cover and land use for a 50-year period (1965–2015) through the application of remote sensing methods and geographical information systems (GIS).

Thus formulated, the subject and the subject of the research cover to a great extent the essence of the topic and the main tasks of the dissertation.

The purpose of the study and the five tasks identified are clearly defined and coordinated with the topic and the overall design and development of the research.

The first chapter presents a general retrospection of the development of the NATURA 2000 concept in Bulgaria and Europe and the research related to the mapping of NATURA sites in Bulgaria. Point 4.1 describes the two model study areas - Dragoman Protected Area and Rayanovtsi Protected Area. It would be appropriate at the end of this chapter to summarize and analyze the development of the Natura 2000 program in Bulgaria and to outline the potential prospects for the development of the two selected areas.

Chapter two presents the theoretical and methodological basis of the study, including remote sensing methods and geographical information systems (GIS). The first and the second part describe the possibilities of application and development of remote methods and GIS. The PhD student refers to specific sources, but it was possible to address and comment in more detail on some fundamental theoretical works in this field.

The third part focuses on the approaches to the classification of remote sensing data and points out that three basic approaches have been applied to the classification of images - classification without training; classification with training and object-based image analysis. It is concluded that, in scientific research, an increasing application is gaining object-based image analysis, which is evolving into an image analysis based on geographic features.

The fourth part deals specifically with the analysis of geographic features (GEOBIA). Possibilities are presented and the main distinguishing feature of object-oriented geographic image analysis versus the pixel-level image exploration approach, namely the ability to apply different scales on the same image or in multiple images taken at one time and the same territory. It was a good idea to include in this part an analysis of the capabilities of object-oriented geographic analysis in relation to the model territories selected for the study.

The fifth part deals with image analysis and classification using specialized eCognition software as one of Trimble's leading technology companies. Details of the possibilities and individual steps of the work are presented.

The last six parts of the chapter characterize the input data used. The study is based on high-resolution satellite images of satellites for which access to the data they received: Pleiades-1A and Pleiades-1B, as well as images from Google Earth. Aerial photographs from 1965, large-scale topographic maps at a scale of 1: 5000 from 1970, average-scale topographic maps at a scale of 1:50 000 from 1986, the Corine Land Cover project of 1990, 2000 and 2006 and accessible data were used as the source of information for the purposes of this study. Additional information was also collected from the field surveys conducted in 2015, 2016, 2017, 2018, 2019.

Chapter Three “Mapping and Retrospective Analysis of the Condition and Implements of the Land Cover and Land Use of the Dragomansko marsh for the period 1965-2015” The first part presents the mapping of the area of ​​the Dragomansko marsh for the period 1965-2015. The state of 1965 based on an aerial photograph, when the process of drying and anthropogenic impact on the wetland is the most -active. Then the Dragomansko marsh was completely drained and turned into arable land. Maps of the variation of the area of ​​the Dragoman swamp for 1986, 1990, 2000, 2006 and 2015 have been compiled for the study and analysis of the changes, using aerial photographs from 1965, large-scale topographic maps on a scale of 1: 5000 from 1970, 1:50,000 scale topographic maps from 1986, Corine Land Cover data from 1990, 2000 and 2006, as well as a high-resolution satellite image taken in 2015 of the Pleiades-1A and Pleiades-1B with a spatial resolution of 0.5 m.

The second part deals with the status and changes of the land cover and the land use according to data from CORINE LAND COVER for the period 1990–2012. Digital thematic maps of spatial distribution of land cover and land use of protected areas in NATURA 2000 “Dragoman” and “Rayanovtsi” have been built for 1990, 2000 and 2012. Fifteen classes of land cover and land use have been identified, classified at level 3 of the CLC nomenclature according to satellite imagery data for 2012.

The third part is related to the assessment of the condition and changes of the Dragoman wetland for the period 1965–2015. The dynamics of the development of the Dragomansko marsh is characterized by fixing the state without a water mirror (aerial photograph from 1965) and tracing the gradual process of restoration of the Dragomansko marsh as a result of the cessation of agricultural activity in the region and water pumping in 2000.

In this part the theoretical statement about the nature and significance of wetlands is developed. Provided that such information is available, it was more appropriate to present this text in the theoretical part of the dissertation by giving it a specific place and supplementing it with other views and understandings about wetlands.

The fourth part analyzes the relationship between karst nourishment and changes in the wetlands of the Dragomansko marsh and the Aldomirovsko marsh. Using different sources and analyzes, the doctoral thesis concludes that the two wetlands - the Dragomansko and Aldomyrovsko marshes have an important role in regulating the water quantities drained by Opitsvet-Bezdenski springs.

Chapter four focuses on the analysis of satellite images based on geographic features. A classification of satellite images without training of the Dragomasko and Aldomirovsko marshes has been made. An image from the Pleiades-1 satellite was used to achieve the purpose of the classification without training, and specialized eCognition 9.1 software was used for the classification itself. Water bodies, wetlands, marsh vegetation, grassland, deciduous and coniferous forest vegetation, open soil sections, open karst sections, industrial sites, roads and buildings are differentiated and analyzed.

The second part focuses on the classification of satellite images with training to represent the vegetation status at the beginning and end of the summer season. Two satellite images of Pleiades-1 were used. There are two test sections - the Karst section "Bezden" and part of the mountain range of Chepun.

The third part presents the results of the Normalized Difference Vegetation Index (NDVI) for selected test sections in the Dragoman protected area using scenes from Pleiades-1 satellite images. Three test sections are covered - Dragomansko marsh, Aldomirovsko marsh and Bezden. The results obtained in the study show a very good vegetation condition, but it cannot serve to differentiate the marsh vegetation from other vegetation types. In general, it can be used to draw the boundaries of water basins as shown on the three maps created (Fig. 4.17, Fig. 4.18 and Fig. 4.19).

The final part presents in a synthesized way the main achievements of the dissertation. Two main groups of results have been identified - 1. A theoretical and methodological approach to the study of land cover and land use by means of modern methods and tools for the analysis of satellite images based on geographical features and 2. Tracking the historical development of a part of the Dragoman protected area, namely the Dragomansko marsh. More specifically, in the context of the topic of the dissertation, the second result was not to be formulated as “historical development” but as “dynamics of the wetland system”.

The candidate submits two publications on the topic of the dissertation, one of which is independent.

The abstract of dissertation is developed in accordance with the text part of the dissertation and accurately and consistently presents the structure, content and main contributions to the presented research.

Three scientific and applied contributions are defined in the dissertation. The first two (1. Methodology for exploration and mapping of land cover and land use using satellite imaging data …………. And 2. A modern approach for the analysis of geographical images based on geographic features (GEOBIA) is applied… ……….) are related to the theoretical and methodological achievements of the work. The third contribution (a retrospective analysis was made and the historical development over a 50-year period (1965-2015) mapped over the area of ​​the most interesting part of the Dragoman protected area - the Dragomansko marsh ………… ..) presents the main achievements work and can be of significant practical importance in the process of management, protection and conservation of wetlands in the region. Particular importances are the developed spatial models of the studied key sites with opportunities for application in the optimization and balance of land use and anthropogenic activities in the region.

Based on the analysis of the results of the applicant's scientific work, I can give a positive opinion for obtaining a doctorate degree in professional field 4.4 Earth Sciences, specialty: Cartography and GIS by Stefan Genchev.

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