University of Sopron

Roth Gyula Doctoral School of Forestry and Wildlife Management Sciences

Programme: E7 Geoinformatics

Modelling and integration of geospatial analytical functions for decision making

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1 Introduction

The main goal of obtaining and modelling spatial data is to know better spatial phenomena and to give solutions to the specific spatial problem, such as administration and monitoring of agricultural land in relation to its use, risk of erosion, and its pollution. The solution to this spatial problem must be supported further by geospatial analytic functions. Also, such solution means supporting the decision-making process which can involve many state institutions from different levels.

1.1 Problem specification

Based on the analysis of the current situation regarding the agricultural land administration and monitoring, it is found that there is no systematized way through which central and local institutions in Kosovo use geospatial tools to support the decision-making process for the administration of the agriculture land, especially the redesignation of agricultural land. The same is happening with two other spatial phenomena, such as agriculture land pollution, and erosion as well.

1.2 Aim and objectives of the study

The primary goal of this research is the modelling and integration of geospatial analytical functions to support the decision-making process regarding agricultural land use protection from three key factors.

The main objectives are as follows:

- Analysis and assessment of the need for a new approach in the administration and monitoring of agricultural land use in Kosovo.
- Developing a conceptual model for geospatial information systems regarding the needs and requirements on administration and monitoring of agricultural land use in Kosovo.
- Conceptual modeling and application of geospatial analytical functions such as retrieval, reclassification and measurement, topological, neighborhood; and connectivity, to support central and local institutions in decision-making process.
- Conceptual modeling of geospatial data including base maps (satellite images, orthophotos, DEM, state or municipal administrative boundaries and cadastral zones) and operational data (cadastral parcels, land classification, land irrigation network, agricultural land consolidation areas, land use, agricultural land pollution areas, actual erosion risk map, and potential erosion risk map).

- Critical analysis in selecting the most suitable software that makes up the comprehensive spatial system.

2 Literature review

The literature review includes the scientific articles regarding the main issues that have been addressed in the thesis, such as: spatial thinking and GIS; decision making support; categories of geospatial functions and their application in the spatial decision-making process.

3 Spatial decision support for government organizations

Several techniques that enable spatial decision support have been analysed, and in detail, the spatial decision-making system has been selected, by further elaborating its components and possible areas of application. Also, the domain of agricultural land use administration is further elaborated.

4 Analysis and needs assessments of geospatial information system for agricultural land use administration and monitoring in Kosovo

The needs assessment is basically based on the legislative framework regarding the protection of agricultural land from redesignation, pollution, and erosion. The law on agricultural land is analysed in terms of the legal competencies that public institutions have in the protection of agricultural land. Competencies have also been converted into user requests from the perspective of using geospatial tools to support the spatial decision-making process.

5 A conceptual modelling of geospatial information system for agriculture land use administration and monitoring in Kosovo

The spatial analytic functions according to the Aronoff classification are further studied, where the required functions are selected to solve specific spatial problems related to the three factors in question. Also, is conducted a conceptual model of the necessary geospatial data, including their sources, obtaining techniques, presentation models, and metadata as well. A critical analysis is done for the open source or proprietary software as an integral part of the overall geospatial system. The fundamental components of the system are: data integration and manipulation; spatial analysis; and visualization. The base concepts of geospatial functionalities are presented by classifying the capabilities into three categories: analytical;

mapping; and report generation. Since the system reflects the requirements and needs of the agriculture land administration in Kosovo, state and local institutions by using it will effectively and efficiently manage information related to the processes of agriculture land administration.

6 New scientific results

1) Analytical tools in government services for the spatial decision-making process

Different categories, such as unstructured, semi-structured, and structured spatial problems faced by government institutions related to land use are analyzed. The needs from the operational and strategic perspectives of the respective institutions to support the spatial decision-making process have been assessed. As a result of needs, different analytical tools and techniques are compared, such as GIS, expert systems, and SDSS. SDSS, with its components, has been reviewed to support the spatial decision-making process to be data-driven, model-driven, and coordinated between decision-makers at different levels. The research done for this scientific result is presented in Chapter 3.

2) Analysis and needs assessments for a new approach in agriculture land use administration and monitoring

The loss of agricultural land areas is analyzed based on the land use maps of 2000 and 2018 for the territory of Kosovo. Results show a loss of 6.33% of the total area. Further, the paper analyzed the current methodologies of the responsible institutions used for the spatial decision-making process related to agricultural land use protection from further degradation. The results showed that the application of spatial analytical tools is almost non-existent. Based on the authorities and responsibilities of the state and local institutions in charge of the administration and monitoring of agricultural land use, a new approach in agriculture land use administration and monitoring is required. Such an approach will greatly impact the protection of agricultural land from eventual degradation. The research done for this scientific result is presented in Chapter 4.

3) Geospatial data modeling for agriculture land redesignation, erosion risk, and soil pollution

Based on real spatial phenomena, the necessary geospatial data, as well as their sources, have been identified. Each identified spatial feature is further defined if it is a base or operational data. A conceptual model with the necessary data has been developed. Based on the analysis of spatial data sources, if specific data is absent, they were created based on some samples. For example, laboratory analysis results for grid

points in an area of 10200 hectares are used. Based on these results, a soil class map is generated. This map is used as input data for updating the soil class attribute in cadastral parcels. The same approach has been followed for developing actual and potential erosion risk maps. In addition, the data quality assessment accompanied by an example using land cover maps is elaborated. The research done for this scientific result is presented in Chapter 5, section 5.4.

4) Geospatial functionalities for administration and monitoring of agricultural land redesignation, erosion risk, and soil pollution

To support the decision-making process related to the administration and monitoring of agricultural land redesignation, erosion risk, and soil pollution, the necessary analytical functions are selected. These functions are classified into four categories: 1) retrieval, reclassification, and measurement; 2) topological; 3) neighborhood, and 4) connectivity. For each category, these functions are analysed and applied through practical examples, using spatial data in an area of 10200 hectares. In addition, the methodology for interoperability among users from different locations is presented. The research done for this scientific result is presented in Chapter 5, section 5.5.

5) Critical analysis on the potential of open-source and commercial software in supporting spatial decision-making

This research includes a comparative analysis for selecting the most appropriate software solutions based on critical aspects such as technological and economic. This analysis is presented in Chapter 5, sections 5.6 and 5.7. Several factors from these two groups have been analyzed, but the cost and usability have been selected as key factors in determining the solution. These two factors are mainly used to analyse the current state of implementation of software systems in relevant public institutions. From this perspective, the proposed software solution represents a solid basis that these institutions can use in the future.

7 References

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