REVIEW

ON DOCTORAL DISSERTATION TITLED "MODEL OF GRAVITATIONAL AND HYDROLOGICAL HAZARDS IN THE OHRID REGION FOR THE SPATIAL PLANNING PURPOSES", PREPARED BY MSC. ENG. LIDIJA TRPENOSKA – SIMONOVIC, SUBMITED FOR THE FACULTY OF FORESTRY

The Scientific – Teaching Council of "Ss. Cyril and Methodius" University - Faculty of Forestry, with the Decision no.0201-844/5 from 14/11/2013 on the XIVth session established the Commission for evaluation of the doctoral dissertation specified above. Members of the Commission are:

1. PhD. Ivan Blinkov, full time professor at "Ss. Cyril and Methodius" University in Skopje, Faculty of Forestry,
2. PhD. Aleksandar Trendafilov , full time professor at "Ss. Cyril and Methodius" University in Skopje, Faculty of Forestry
3. PhD. Makedonka Stojanovska, associate professor at "Ss. Cyril and Methodius" University in Skopje, Faculty of Forestry
4. PhD. Aleksandar Stojmilov, full time professor at "Ss. Cyril and Methodius" University in Skopje, Faculty of Natural Sciences and Mathematics, retired
5. PhD. Katerina Donevska, full time professor at "Ss. Cyril and Methodius" University in Skopje, Faculty of Civil Engineering.

After examining the submitted doctoral thesis, the Commission has the honour to submit to the Scientific – Teaching Council of the Ss. Cyril and Methodius University - Faculty of Forestry, the following

REPORT

The doctoral dissertation of MSc. Eng. Lidija Trpenoska - Simonovic, titled "Model of gravitational and hydrological hazards in the Ohrid region for the spatial planning purposes" is made in accordance with the regulations. The thesis contains a total of 166 pages of basic text in normal spacing, 10 previous pages and 4 pages attached. It is presented in a contemporary scientific approach, using methods recognized internationally.

In addition, a geospatial database for the research area and geospatial models regarding the topic is created as a background material of the dissertation.

The material presented in the thesis is divided into:

Previous article:

1. Title and gratitude, on two (2) pages;
2. Abstract in Macedonian and English on two (2) pages;
3. Contents of two (2) pages;
4. List of tables and figures on four (4) pages;

And

Basic text which is divided into:

1. Introduction on 29 (twenty nine) pages;
2. Previous studies on 16 (sixteen) pages;
3. Research methodology on 17 (seventeen) pages;
4. Geospatial features of the research area on 27 (twenty seven) pages;
5. Results and discussion on 65 (sixty five) pages;
6. Conclusions and recommendations on seven (7) pages and
7. References on five (5) pages.

The questionnaire that was used for hazards' gradation by the Delphi method is presented on 4 pages in the attachment.

In the Abstract, in accordance with the standards for writing of scientific thesis, the most important parts of all the sections of the thesis are presented in Macedonian and English.

The working context is presented in the first two chapters. These chapters provide answers to the basic questions of such thesis: What is being studied? Why is this an important issue? What did we know about this issue before we made this thesis? How will this study advance our knowledge?

The structure of the **Introduction** is set correctly starting from the most general information and definitions about the issues (natural hazards, spatial planning and processes' modeling) and gradually going further by explaining the issue, focusing finally on the specific problem that is studied. The vulnerability of the populated areas and damage from natural hazards is a testimony to human life in conflict with the environment, partly as a consequence of spatial planning that failed to adequately consider the hazards and risks in making decisions about the development and land use. To avoid/mitigate the negative impact of natural hazards, it is necessary to determine their spatial representation, intensity and frequency, all in relation to the spatial dispersion of the settlements and other structures significant to humans.

The main objective of this thesis is to find an optimal procedure-access for analysis, display and adjustment of the natural gravitational and hydrological hazards in spatial planning, and also, to find a model that includes the areas that may be affected by hazards, as well as the contents of space, existing and planned, that needs protection. The model that emerges from this study should facilitate and visually approach the information not for single, but for complex hazards, which increases the likelihood that it will be used in the process of planning /decision making.

To get to the main goal, several objectives are set as follows:

- What are the approaches regarding the making of models for gravitational and hydrological hazards in the Republic of Macedonia and how much they are in accordance with the current approaches in Europe?
- What is the most appropriate form of preparation, analysis and presentation of geospatial database of the features necessary for modelling of the dangers and risks of hazards in the Republic of Macedonia, considering the availability of the basic data?
- What is the difference between the single hazard and multi-hazard approach to the needs of spatial planning?
- What are the optimal procedures for making a model of gravitational and hydrological hazards for the needs of the spatial planning in RM?

The theoretical basis and ***previous researches*** are presented on 16 pages. Part of the research aimed to compare the approaches to making hazards and risks maps in the Republic of Macedonia with the modern European approaches for hazards' modelling. In the first part the approaches that have been practiced in the Republic of Macedonia till now are worked out. Hereafter the current approaches and models that are used in Europe are being analyzed, with special emphasis to researches conducted by ESPON, ARMONIA and other projects. The theses of Philipp Schmidt - Thomme are analyzed in detail. There is compliance in the treatment of hazards as a risk i.e. limiting factor for development of areas affected by hazards. The interdisciplinary approach in deciding when planning the future development and use of modern GIS technologies are other common features. The lack of established standards for the manner of mapping, content and details (scale) of the displayed hazards is also common. The key difference is

illustrated in the display and calculation of the risks, which expressed as funds are not present in the planning in the Republic of Macedonia.

In the next chapter the ***Research methodology***, the candidate focuses on the subject of the dissertation. The work methodology is adjusted to this type of research. A qualitative and quantitative method for the analysis of primary and secondary data is used, which give answers to the research tasks. The methodology of work is based on creating of the necessary basic parameters and files for further analysis, which is obtained through field measurements, determination of the measured elements and collection of required paper, text, analogue and digital maps.

The field research includes communication with the institutions that have their own responsibilities in the areas of planning, and dealing with natural hazards. To get to the information that can be used to create spatial models, the following methodology is used:

1. Identification of natural hazards and spatial contents sensitive to analysed hazards;
2. Data processing and creating geodatabase;
3. Determining of the groups of information according to their structure and character, the way of their organizing, manipulating and analyzing;
4. Application of multiple GIS tools and methods for generating, classification and combining of information and
5. Detailed analysis of the applied methods and approaches and determining the optimal method and approach for the level and detail of the available information in the research area, and the whole country as well.

The basic geodatabase in this thesis is formed as a personal geodatabase, using the software ArcGIS 10.1. Part of the data (basic data, topographic maps, toponyms etc.) is taken from the central geodatabase of the Spatial Planning Agency (SPA).

The next chapter ***Geospatial characteristics of the region***, which covers 27 pages, presents the results of the prepared integrated geospatial model of the terrain of the research area that includes the municipalities of Ohrid and Debarca. This particularly created geospatial model was a starting base for further analysis and modelling. This geospatial model processes all the necessary natural factors (geological substrate, pedological features, climatic characteristics, etc.) first. In the further part the study pays attention to the necessary socio-economic characteristics of the region that are used in the development of the risk models. Each of the required parameters is geospatially defined, by its scope, geographic location, and by type, and for some parameters by intensity too. They are all produced in the so-called GIS - environment.

The results of the research including the discussion on the obtained results are presented on 65 pages.

During the presentation of the results the chapters which deal with models of susceptibility i.e. the risk models are separated.

In general, the results of the comparative analysis of approaches and procedures in ArcGIS software for creation of such models are presented and the most appropriate approach, according to certain criteria for further software analysis is selected. As an output, there is a map given in the text.

In the first part of the results the models of single and complex susceptibility are presented.

In this thesis single models are created for susceptibility to drought (based on the classification of land cover with parameters adopted from the Center for Drought Management of South-East Europe), erosion and sedimentation (according to the methodology used in making the map of the erosion of the Republic of Macedonia), flooding (coastal, tributaries of the Ohrid Lake, and Lake Slatina), landslides and

landfalls). To get a model that shows the susceptibility of the terrain to landslides and landfalls, a model that combines data from the geological stability and inclinations of the terrain was developed. Thus a unificated valuation is made, i.e. the steepest parts and the rocks that are worst in composition are valued weight 3. Value 2 is assigned to relatively mild slopes and conditionally unstable terrain, and value 1 gets the mild slopes and stable rocks. Further on, the result is being treated as a single disaster.

The model of the complex susceptibility to hazards is obtained by combining the results of single hazards. Thereby the drought is not taken in the analysis because it does not affect the generated values for which the vulnerability is modelled. The landslides and landfalls are treated as a single disaster, because the conditions that lead to their occurrence are equal, i.e. they mean proper slope and geological structure. The erosion participates in the analysis with its strongest categories, which are first, second and third category of erosion. According to the evaluations of endangerment prepared by the local self-governments, three types of zones that are prone to flooding are selected: coastal, along certain waterways and fields under the Lake of Slatino. For the analysis of the susceptibility to landslides/landfalls, the classified geologic map and slope of the terrain generated from a 3D model was used. The model that unifies the mentioned hazards is generated so that each disaster is represented by a raster (grid) of a binary nature. Areas where there is no natural disaster, or the expected intensity is small, receive zero value, and the areas that may be affected by the disaster that has the potential to cause greater to significant damage receive value that identifies the disaster. With weight values set in such way and their combination - summing up, we get the summary map of hazards.

The space capacity refers to the extent to which a particular type of landscape or area can adapt to changes, without a significant effect on his character, or globally on change of the type of landscape. There is no formula that could calculate the spatial capacity, but some optimal or minimal values that guarantee conditional constancy of the character of the area can be adopted. In the thesis the spatial capacity arises from its purpose, wherein the analysis is based on the constancy of the spatial character, namely the preservation of the character of each of its elements (settlements, cultural heritage areas, natural areas, etc.). The main feature of the analysed area is the unequal distribution of the population, public functions (institutions), immovable cultural heritage and economic values. The dominance of the city of Ohrid is apparent in all of the above mentioned areas. This fact affects the choice of the method for evaluation of the space elements by granting a weight coefficient. If we use methods that proportionally to the number of residents generate the raster for their distribution, the outcome will be that apart from Ohrid, other places have no value, i.e. their contribution is insignificant. The same problem occurs in the analysis of public functions (education, healthcare) and cultural heritage. To illustrate the applicability of the methods for reclassification of the population density, several attempts were made by the following methods: standard deviation, natural breaks and quantils.

The results indicate that only the last method respects all of the settlements, regardless of their size according to the number of residents. To find the model that shows the impact of the disaster on different spatial structures, it should be determined which disaster affects which structure. The great picture which is obtained by a spatial plan and defines the macro - locations of hazards and created values should serve as an indicator of the need for detailed research in all of the areas where susceptibility to hazards and vulnerability of them overlap. The simplest solution is to develop simultaneously the susceptibility maps - or risk maps and maps of created values to simplify and then overlap them.

Two approaches for creation of a model of a complex risk are applied in the thesis.

The first approach, which is simpler, is a simple accumulation of the areas prone to natural hazards and socio-economic elements vulnerable to hazards. This approach gives a picture of the areas that are more or less susceptible to one or more hazards, but gives no information for the risk intensity.

The second approach is actually multi-criteria estimation of the hazards' intensity. Crucial point is the determination of the weighting index of different parameters, thus allowing perception of the risk intensity too. The risk measurement includes the subjective factor, i.e. the experience of the disaster, and it is possible with the use of feedback. The Delphi method is used for this purpose, which can generate measurable factors of more hazards to assess the overall risk of a certain area.

Following the principle of a sum of the valued hazards, the model and a map that gradates the space from high to low risky are generated, in terms of the hazards that are considered in the analysis. Two variants of combining the susceptibility to hazards are performed. In the first variant, the three rasters (hazards) have equal weight coefficient and in the second variant, which emerged from the analysis of the Delphi method, the hazards have different coefficient from 1-3. With further reclassification of models obtained by both variants, in three categories, according to the method of equal intervals, minor differences were obtained, which, expressed in surface measure, amount to 3-12%, and on the other hand they represent respectively 1.8% , 1.79% and 0.01% of the total area of the analysed space for the first, second and third degree of risk. Hence, according to the nature and accuracy of a spatial plan, and having on mind the insignificant difference in the spatial coverage, in case of lack of data, or expertise, the first variant can be recommended, which gives a picture of the cumulative risk of natural hazards in a certain area.

On the basis of all the analysis, the candidate cites the optimal procedure for creation of a model of gravitational and hydrological hazards that consists of:

- Determining the susceptibility to hazards as a function of natural features;
- Creation of a thematic layer, weighting, reclassification and separation of areas with higher degree of susceptibility to each disaster (landslides/landfalls, erosion and flooding);
- Assessment of vulnerability, which is a function of the built/planned structures;
- Creation of layers for settlements, public functions, cultural heritage and infrastructure, in which the potential risk of hazards integrally shows the space in which the values - the existing or planned are settled, and it is treated as vulnerable and
- Interpolation of single maps in a summary map of hazards by the usage of some mathematical functions. The interpolation can be:
  a) The simple accumulation of the areas prone to hazards (allocated higher categories), with which information about the susceptibility and the type of the hazards present in the area is got.
  b) Multi-criteria estimation of the hazards' intensity, for which it is essential to determine the weight index of the parameters that create the model of hazards/risks, where hazards are valuated, and their sum is calculated, and a map that gradates the space from low to high risky is created. In the lack of verified expertise, equal weight ratios are applied, with which for the needs of a spatial plan we get a picture of the cumulative risk (intensity) of natural hazards in a certain space.

The application of this procedure is expected to support the interdisciplinary, comprehensive approach to spatial planning.

CONCLUSION AND PROPOSAL

From the data presented above, it can be concluded that the doctorial thesis entitled "Model of gravitational and hydrological hazards in the Ohrid region in the spatial planning", prepared by MSc. Eng. Lidija Trpenoska - Simonovic is an original and independent scientific thesis, which is actually a multidisciplinary one, because it covers not only related areas of the research but also, more research areas spaced in three research fields (natural and mathematical sciences, technical-technological sciences and biotechnical sciences) which gives a significant contribution to science and practice. The approach and procedures defined by the research are general and applicable to the entire state and beyond. An approach and procedures defined within this research are general and applicable for the whole state and wider.

The results obtained in the studies, the findings and conclusions of them certainly have a special significance for the science of the area of land and water, and is associated with spatial planning, forest environment, water economy, land policy, geo-information and risk management, but also for the practice in these areas.

Considering all of the aforementioned, the Commission positively evaluated the doctoral dissertation and has the honour and pleasure to propose the Professors' Council of the Faculty of Forestry - Skopje, to accept it as an original and independent scientific paper and to initiate proceedings for its public presentation.

12/14/2013

COMMISSION

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