Universitatea Transilvania din Brașov

HABILITATION THESIS

SUMMARY

TITLE: USING MODERN WORKING METHODS TO ESTIMATE SUSCEPTIBILITY TO FLASH FLOODS AND FLOODS

Domain: Civil Engineering and Facilities

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The habilitation thesis entitled "Using modern working methods to estimate susceptibility to flash floods and inundations", developed in the field of Civil Engineering and Installations, summarizes the scientific and professional activity carried out by the author in recent years and highlights future research directions. The work is part of a highly topical field, given the increase in the frequency and intensity of extreme hydrological phenomena due to climate change, as well as their significant impact on the environment, infrastructure and society. The general research direction of the present research work refers to the use of modern methods to estimate susceptibility to flash floods and floods.

The thesis is structured according to the requirements of CNATDCU, being organized into two major components: (i) presentation of scientific and professional achievements and (ii) plans for the evolution and development of the academic career. The first part represents the scientific core of the work and includes the results of research published in prestigious journals, indexed in international databases (Web of Science, Q1 and Q2), as well as contributions obtained within national and international research projects.

The introductory chapter presents the general context of the research, highlighting the importance of studying flash floods and floods as some of the most frequent and destructive natural hazards. The need to develop modern and efficient methods for identifying vulnerable areas and supporting the decision-making process in risk management is emphasized. At the same time, the scientific works that underlie the thesis are presented, which constitute the foundation of the author's original contributions.

Chapter 1 addresses the estimation of flood susceptibility using the Fuzzy-Analytical Hierarchy Process (Fuzzy-AHP) method. This approach combines multi-criteria analysis with fuzzy logic, allowing the integration of uncertainty and subjectivity associated with expert judgment. Relevant geospatial data are analyzed, and the results are validated by statistical methods, such as the ROC curve. The study demonstrates that the proposed model provides robust and reliable results, being suitable for mapping flood-prone areas and supporting authorities in decision-making.

Chapter 2 is dedicated to the assessment of flash flood potential using decision tree methods and hybrid models. Techniques such as Weights of Evidence, Logistic Model Tree, Rotation Forest and Alternating Decision Tree are used, in combination with predictor selection methods. The results highlight the superiority of hybrid models over individual models, offering higher predictive

capacity and better identification of susceptible areas. Validation of the models through statistical indicators confirms their accuracy and usefulness in the analysis of hydrological hazards.

Chapter 3 extends the analysis by integrating artificial intelligence and machine learning techniques in the assessment of flash flood susceptibility. Models such as logistic regression, Random Forest, Support Vector Machine, Classification and Regression Tree and artificial neural networks (Multilayer Perceptron) are applied, as well as hybrid combinations thereof. The results show that artificial intelligence-based models, especially hybrid ones, achieve high performance in predicting and mapping vulnerable areas, demonstrating the potential of these techniques in the field of applied hydrology.

An important aspect of the thesis is the rigorous validation of the results, achieved by using ROC curves and other statistical indicators, which gives credibility and robustness to the conclusions obtained. Also, the limitations of the research are discussed, such as the dependence on the quality of the input data or the influence of subjectivity in expert-based methods, and directions for improvement for future research are proposed.

The author's original contributions consist in the development and application of innovative hybrid models for assessing susceptibility to floods and flash floods, the integration of multi-criteria analysis techniques with machine learning methods and the use of complex geospatial data sets. These contributions have been validated through impactful scientific publications and through the practical applicability of the results obtained. The paper also highlights the author's ability to coordinate and implement research projects, as well as to integrate their results into solutions applicable at the institutional level.

From an application point of view, the results of the thesis can be used by institutions such as the National Institute of Hydrology and Water Management and by local and central public authorities, in order to develop early warning systems, evacuation plans and risk reduction strategies. Thus, the thesis contributes not only to the development of scientific knowledge, but also to the improvement of natural hazard management practices.

The second part of the thesis is dedicated to presenting the author's academic and professional development, highlighting the educational path, research activity and achievements. University studies (bachelor, master, doctorate), professional experience and involvement in research and publication activities are presented. This section demonstrates the continuity and coherence of the author's scientific concerns, as well as the consolidation of a solid academic profile.

Finally, the chapter dedicated to the career development plan outlines future research directions, focused on the integration of emerging technologies, such as artificial intelligence, in the analysis of natural hazards, the development of advanced predictive models and the expansion of international collaborations. The intention to contribute to the development of operational decision support systems and the training of new generations of specialists in the field is also emphasized.

In conclusion, the habilitation thesis demonstrates the scientific maturity of the author and his ability to develop independent and relevant research directions at national and international level. Through its interdisciplinary nature, complex methodological approach and applicability of the results, the work makes significant contributions in the field of hydrological risk assessment and aligns with the requirements and standards imposed by CNATDCU.