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# Review

#### on the dissertation titled

## " Spatial analyses and high-mountain ecosystem condition

## and services assessment in Rila Mountains"

for the awarding of the educational and scientific degree "Doctor" in Scientific Field 4. Natural Sciences, Mathematics, and Informatics, Professional Field 4.3. Biological Sciences, Scientific Specialty "Ecology and Ecosystem Conservation"

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#### Prepared by: Assoc. Prof. Dr. Svetla Vuleva Bratanova-Doncheva,

Professional Field 4.3. Biological Sciences, Scientific Specialty "Ecology and Ecosystem Conservation", appointed as a member of the Scientific Jury by Order No. 96/23.12.2024 of the Director of IBER-BAS.

#### SHORT BIOGRAPHICAL DATA OF THE CANDIDATE

Kostadin Marinov Katrandzhiev graduated from New Bulgarian University in 2012 with a bachelor's degree in ecology and a master's degree in environmental management. From January 1, 2016, to December 31, 2018, Katrandzhiev was a full-time PhD student in the "Ecosystem Research" section at the Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences (IBER-BAS). After completing the regular PhD period, he was discharged with the right to defend his dissertation. The dissertation was discussed and approved for defense during an extended session of the "Ecosystem Research, Ecological Risk, and Conservation Biology" department at IBER-BAS, held on October 29, 2024.

Between April 2019 and December 2021, the PhD candidate participated in the National Program for Young Scientists and Postdoctoral Researchers with two projects. From April 2019 to January 2020, he took part in specialized training at the Institute of Space Research and Technology (ISRT) at BAS under the supervision of Prof. Rumen Nedkov. This training focused on satellite data processing—multispectral images with high spectral and radiometric resolution, working with specialized software and GIS environments, and calculating vegetation indices (VI) such as NDVI, NDWI, and NDGI based on multispectral images from Landsat and Sentinel-2 satellite sensors.

The total number of credits accumulated during the PhD program is **474**. The documents submitted by the candidate comply with Article 39 (1) of the Regulations on the Conditions and Procedures for Obtaining Scientific Degrees and Holding Academic Positions at IBER-BAS.

Kostadin Katrandzhiev approached the assigned topic, which is both important and necessary for ecosystem research and relatively new to IBER and the scientific community as a whole, with professional courage and great enthusiasm. His dissertation summarizes the results of extensive research, including intensive field and office work, the adoption of new methods, an in-depth review of specialized literature, and the processing and analysis of a vast amount of data. While working on the topic, the PhD candidate demonstrated a creative approach, responsibility, diligence, and independence in completing the assigned tasks, as well as deep analytical thinking when analyzing diverse scientific literature and interpreting the obtained results. He successfully mastered and applied new concepts in modern ecology, a wide range of new methods, contemporary data analysis approaches, and new indices for assessing the functional activity of high-mountain ecosystems in the context of climate change.

Alongside completing his PhD program, Katrandzhiev actively participated in research and applied scientific projects funded by various institutions, thanks to his personal and professional qualities. This allowed him to refine his knowledge and skills and gather a significant volume of material, which was incorporated into his dissertation. His work on projects within the "Ecosystem Research" section provided opportunities for collaboration with colleagues from other Bulgarian scientific organizations and renowned scientists from various European countries.

As his academic supervisor, my direct impressions of his work on the dissertation allow me to affirm that it is entirely his own work.

The dissertation, titled **"Spatial analyses and high-mountain ecosystem condition and services assessment in Rila Mountains"**, follows a format of bound articles and consists of a total of 58 pages of separate text and 87 pages of bound publications related to the dissertation topic. It contains 10 main sections, 5 tables, and 17 figures. The list of cited literature includes 73 references in both Latin and Cyrillic scripts.

Publications are:

1. Katrandzhiev, K.; Gocheva, K.; Bratanova-Doncheva, S. *Whole System Data Integration for Condition Assessments of Climate Change Impacts: An Example in High-Mountain Ecosystems in Rila (Bulgaria)*. Diversity 2022, 14, 240.

2. Katrandzhiev, K. *APPLICATION OF REMOTE SENSING FOR HIGH MOUNTAIN ECOSYSTEM CONDITION ASSESSMENT (SOUTH WEST RILA MOUNTAIN - BULGARIA*). Ecological Engineering and Environment Protection 2018, No 2, p.35-40.

3. Katrandzhiev, K. and Bratanova-Doncheva, S. *Spatial Distribution of High-Mountain Ecosystems—Application of Remote Sensing and GIS: A Case Study in South-Western Rila Mountains (Bulgaria*). Silva Balcanica 2019, 20, 3, 57–69.

4. Annex 1 – an article prepared for submission, with the working title: "Data Fusion for Ecosystem Services Assessment: a Case Study in Bulgarian South-western Rila Mountains".

#### RELEVANCE AND SIGNIFICANCE OF THE SCIENTIFIC RESEARCH PROBLEM

Ecosystems in high-mountain regions are unique natural systems characterized by a distinct set of structural and functional features. These systems are highly adapted to extreme climatic conditions, including low temperatures, intense ultraviolet radiation, and a short growing season. Specific vegetation types, vertical species distribution, efficient energy utilization, and adaptive nutrient cycles are among the key characteristics that enable these ecosystems to function despite the challenges of the high-mountain environment. Understanding these aspects is crucial for developing conservation strategies and sustainable management approaches for these fragile ecosystems, especially in the face of global climate change and increasing human impact.

The spatial analysis and assessment of ecosystem services at the upper forest line is a multifaceted process requiring the integration of various data sources and methodologies. By combining remote sensing, GIS analysis, and field studies, reliable and detailed assessments of ecosystem conditions and functionality can be obtained. These assessments are essential for adapting management strategies to climate change and ensuring the sustainable use and conservation of forest ecosystems.

Conducting a spatial analysis and evaluation of the state and ecosystem services of ecosystems at the upper forest line requires an integrated approach that incorporates both remote sensing methods (satellite observation, GIS) and field research.

The NDVI (Normalized Difference Vegetation Index) and NDWI (Normalized Difference Water Index) indices, utilized in the dissertation, are important tools in remote sensing that provide valuable information on ecosystem condition and functionality. The use of NDVI and NDWI allows researchers and natural resource managers to monitor the effects of climate change on vegetation and water balance, thereby supporting the development of more effective

adaptation and conservation strategies for ecosystems across large and inaccessible highmountain areas.

### MAIN SCIENTIFIC CONTRIBUTIONS

This study provides several significant contributions, both in scientific and applied aspects. Three scientific, four methodological, and two applied contributions have been identified, effectively representing the work carried out and the results obtained. Their theoretical significance is as follows:

- Enhancing scientific understanding of high-mountain ecosystems: The study deepens knowledge about the structure and functioning of ecosystems at the tree line by analyzing specific adaptation conditions. This knowledge is essential for developing ecological theories and models.
- Methodological innovations: The use of remote sensing methods and idexes (such as NDVI, NDWI, and GIS analysis) creates an integrated approach that can be applied to other ecological studies. This enriches scientific methodology and allows for more accurate and large-scale assessments of ecosystems and their services.
- Support for sustainable management: The data and findings from the study provide a foundation for developing effective management strategies for forest ecosystem protection. This helps in adapting to climate change and reducing the risk of natural resource degradation.
- Informing policy-making and decision-making processes: Mapping and quantitative assessment of ecosystem services enable informed decision-making at local and national levels regarding sustainable development, biodiversity conservation, and the rational use of forest resources.

In summary, this study contributes to expanding scientific knowledge, improving methods for assessing ecosystems and ecosystem services, and supporting the development and implementation of practical solutions for sustainable management and climate change adaptation.

#### REMARKS

I have previously shared my critical remarks with the PhD candidate during the approval process—most of them have been acknowledged and addressed in the final version. The candidate demonstrated excellent focus, organization, and work ethic, managing to complete his dissertation while actively participating in several significant projects at IBER. I have noted some minor inaccuracies, but they do not diminish the quality of the dissertation.

#### CONCLUSION

In developing his dissertation, **Kostadin Marinov Katrandzhiev** demonstrated the qualities of a motivated, responsible, and competent researcher with broad scientific interests, methodological precision in field and remote research, and depth in data analysis, interpretation, and result definition.

The presented scientific, methodological, and applied contributions in the dissertation confirm the PhD candidate as a well-rounded researcher with extensive methodological training and indepth knowledge of ecosystem structure, function, and service assessment.

Based on the above, I recommend that the esteemed members of the Scientific Jury, appointed by the Scientific Council of IBER, award Kostadin Marinov Katrandzhiev the educational and scientific degree "Doctor."

Sofia, 17.03.2025

**Prepared by:** (Assoc. Prof. Dr Svetla Bratanova-Doncheva)