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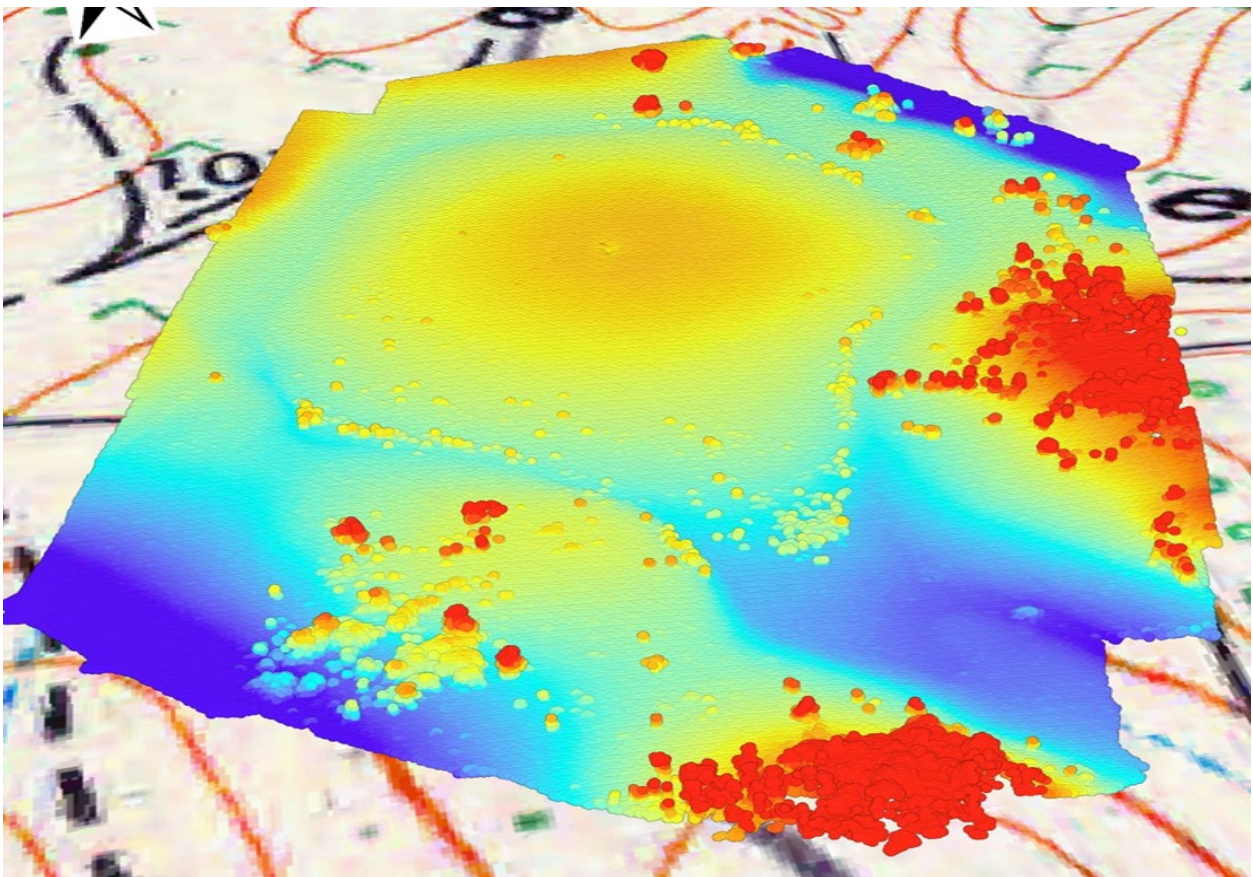


BOOK OF ABSTRACTS

International Conference on Wetlands Monitoring
and Management in the Carpathian Region

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and Management in the Carpathian Region**



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FOREWORD

Dear Readers and Conference Participants,

We are pleased to present this Book of Abstracts, which brings together the contributions of the WeVaRe Conference on Wetlands Monitoring and Management. As the opening text of our proceedings reminds us, wetlands rank among the most valuable yet vulnerable ecosystems on Earth. They sustain biodiversity, regulate climate, purify water, mitigate floods, and support livelihoods. Despite these irreplaceable services, wetlands continue to degrade at an alarming rate due to land-use change, climate variability, unsustainable practices, and – perhaps most critically – the persisting gap between scientific knowledge and decision-making.

This conference directly addresses that gap. It is built on the conviction that integrated, interdisciplinary dialogue between science, policy, and practice is not optional but essential. Rapid advances in monitoring technologies – remote sensing, UAVs, LiDAR, geospatial analysis – have transformed our ability to assess wetland dynamics. Yet technology alone is insufficient. These tools must be effectively linked with economic valuation, governance frameworks, and on-ground management strategies to support evidence-based policies and the Sustainable Development Goals.

The WeVaRe Conference offers a unique platform for sharing results from the WeVaRe Project – *Introduction of Monitoring the Wetlands of International Importance in the Carpathian Region* – while also fostering broader scientific exchange at national and international levels. By gathering researchers, practitioners, public authorities, and stakeholders, we promote the integration of environmental and economic perspectives, emphasising wetlands not only as natural assets but as key contributors to regional development and resilience.

The abstracts collected in this volume are organised under two major thematic sections, reflecting the conference’s dual focus on scientific monitoring and economic valorisation:

- **Section A: Scientific, Technical, and Environmental Aspects** – covering topics such as remote sensing, wetland mapping, climate change impacts, hydrological processes, biodiversity conservation, restoration, nature-based solutions, and ecological assessment methods. The papers in this section present cutting-edge research on sites ranging from the Maramureş Mountains Natural Park and Lake Synevyr (Ukrainian Carpathians) to former mining areas in northwestern Romania, peatlands, river floodplains, and the Upper Tisa Natura 2000 site. Methodologies include UAV-LiDAR fusion, GIS modelling, multi-sensor satellite analysis, airborne laser scanning, and integrated geospatial database frameworks.
- **Section B: Economic, Social, and Policy Dimensions** – addressing economic valuation of ecosystem services, cost–benefit analysis, sustainable regional

development, green and circular economy approaches, funding mechanisms, governance, stakeholder engagement, community-based management, and land-use conflicts. The papers explore innovative themes such as applying the Analytic Hierarchy Process to determine stakeholder priorities, reframing wetland governance through citizen science and education, the role of modular constructions for nature observation, blockchain for wetland protection financing, cultural institutions in community engagement, the water–energy nexus, eco-packaging and green consumers, and consumer perceptions of return-guarantee systems in wetland areas.

Together, these contributions address current policy priorities related to climate change adaptation, biodiversity conservation, the green economy, and sustainable land-use planning. More importantly, they translate scientific results into practical solutions, encourage stakeholder engagement, and strengthen cooperation between academia, public institutions, and local communities.

We believe that this Book of Abstracts is a significant contribution to achieving the objectives of the WeVaRe project and to advancing integrated wetland management at regional, national, and European levels. By enhancing awareness, improving management practices, and supporting long-term sustainable wetland governance, the WeVaRe Conference plays a strategic role in reversing the degradation of these precious ecosystems.

We thank all authors, reviewers, and participants for their dedication and welcome you to an inspiring and productive conference.

Sincerely,

The WeVaRe Conference Organising Committee

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Monica-Liliana Marian¹, Bogdan Vasilescu¹, Zorica-Marcela Voşgan¹
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Abstract

The Natura 2000 site "Tisa Superioară" (Upper Tisa) extends along the Tisa River, the natural border between Romania and Ukraine. It was included in the network of protected natural areas due to biodiversity elements of community interest: characteristic wetland habitats and species of fish and amphibians. Although only two types of habitats of community interest are mentioned in the site's standard data form: 91E0 - Alluvial forests with *Salix alba* and *Populus alba*, and Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*), in the Tisa floodplain between Bocicoi and Remeţi, within a mosaic vegetation cover of agricultural crops, another 18 types of habitats of conservation interest were identified and mapped between 2020-2025, ranging from wet meadows to palustrine plant associations. The conservation status of the faunal species of conservation interest listed in the standard form depends on the conservation status of these habitats: 1166 *Triturus cristatus*, 1193 *Bombina variegata*, 1220 *Emys orbicularis*, 1105 *Hucho hucho*, 1130 *Aspius aspius*, 1131 *Leuciscus souffia*, 1138 *Barbus meridionalis*, 1146 *Sabanejewia aurata*, 1157 *Gymnocephalus schraetzer*, 1159 *Zingel zingel*, 1160 *Zingel streber*, 1163 *Cottus gobio*, 9903 *Eudontomyzon danfordi*. The area of habitat 91E0 is limited, under 5%, and most of the surfaces are occupied by coenoses with an advanced degraded structure; a smaller fraction of the areas is undergoing reforestation with riparian phytocoenoses. Their chance of reaching maturity is reduced due to very intense anthropogenic pressures. Many of the habitats shown on the vegetation map, created following the inventories and not previously mentioned or mapped, are under high pressure, being fragile and vulnerable. Their degradation is synchronous with that of the forest habitats and, at the same time, accelerates the process of deterioration of the vegetation cover across the entire Natura 2000 site. This study analyzes the distribution of habitats in the Tisa floodplain, their correlation with abiotic factors, as well as the anthropogenic pressures and impact that generate their loss and/or deterioration.

Keywords: *Natura 2000 network, Tisa River, wetland habitats, anthropogenic pressure, biodiversity conservation, habitat mapping, alluvial forests, environmental degradation.*

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BEHAVIOR OF MOUNTAIN WETLANDS UNDER THE INFLUENCE OF ENVIRONMENTAL AND ANTHROPOGENIC FACTORS MONITORED BY GEOMATICS TECHNOLOGIES: A LITERATURE REVIEW AND BIBLIOMETRIC ANALYSIS

Virgil Mihai Rădulescu¹, Gheorghe M. T. Rădulescu¹, Sanda Mărioara Nas¹, Adrian Traian Rădulescu¹, Dorel Gușat¹, Petru Daniel Măran¹, Norbert Kiss²

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Abstract

In a unique combination of land and water, wetlands are ecosystems that form a special ecological balance. The biodiversity of wetlands is a strong point of this "unique" picture, complemented by the fact that they are also indispensable ecosystems for maintaining the natural balance. However, wetlands are among the most threatened ecosystems in the world, with estimates suggesting that more than a third of them have disappeared in the last century. The causes are diverse, some common to all types of wetlands, others specific to certain areas or climatic conditions in which they are found. Although a multitude of studies address various issues facing wetlands, from threats to monitoring methods, very few focus on mountain wetlands. Even in this case, however, the issues addressed do not cover the entire range of threats, solutions, and, in general, management solutions. The entire approach takes into account that the general support for the entire picture of territorial information is of a geomatics nature, the end result being a GIS system that hosts all relevant territorial information. The objective of this study is to identify areas where there are gaps in the existing literature on environmental or anthropogenic factors that negatively influence the evolution and existence of wetlands, with a particular focus on those located in mountainous areas, together with the techniques and technologies used to monitor them. To achieve this objective, the most well-known threat factors and technologies used in monitoring the current status, especially those based on geomatics solutions, were identified as a concern in the works published to date, through a systematic search in the Scopus database, with ISI Web of Sciences validation and selection of results according to well-established criteria, designed to bring the information closer to the purpose and theme of the paper. Subsequently, the study used a bibliometric analysis, exploring the research areas reflected in the specialized literature that refer to the subject addressed. The findings indicate a lack of scientific investigations into the influence of environmental factors affecting mountain wetlands, as well as geomatics methods and technologies for investigating their condition at a given moment. The research provides a comprehensive understanding of how both the issue of threats and the monitoring methodology are addressed in the literature, with practical implications for the development of both integrated monitoring solutions and effective territorial management plans for these ecosystems.

Keywords: *Wetlands; Climate change; Pollution; GIS; UAV; Geomatics technologies*

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INTEGRATED MONITORING OF CARPATHIAN WETLANDS USING MULTI-SOURCE DATA AND GIS-BASED ANALYSIS

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Abstract

Wetlands provide essential ecosystem services, including water regulation, biodiversity support, and climate change mitigation, yet they are increasingly threatened by hydrological alterations, climate variability, and insufficient monitoring systems. This study aims to develop and implement an integrated monitoring framework for wetlands of international importance in the Carpathian region within the WeVaRe project. The approach is based on the integration of multi-source data, including hydrological measurements (water levels, flow, and water quality), meteorological and climatological parameters (temperature, precipitation, evapotranspiration), and remote sensing products derived from Sentinel-1 and Sentinel-2 satellite imagery, digital elevation models, and spectral indices such as NDVI and NDWI. All datasets were subjected to rigorous quality control procedures, including homogeneity testing, outlier detection, and gap-filling methods, and were subsequently integrated into a GIS-based database enabling advanced spatio-temporal analysis and modeling. The results highlight significant seasonal variability in water levels, soil moisture, and vegetation dynamics in the studied wetlands (Tăul lui Ciomau and Iezeru Mare), with clear correlations between climatic conditions and ecosystem responses. Furthermore, multi-criteria GIS models in ArcGIS Pro allowed the identification of areas exposed to risks such as flooding, drought, and land degradation, improving the spatial accuracy of environmental assessments. The integrated monitoring system enhances the understanding of wetland dynamics and supports the development of predictive scenarios under changing climate conditions. These findings provide a robust scientific basis for adaptive wetland management, facilitating data-driven decision-making, conservation planning, and cross-border environmental cooperation. The proposed framework demonstrates the added value of combining remote sensing, in-situ observations, and GIS technologies for sustainable wetland monitoring and management.

Keywords: *climate variability, gis, remote sensing, risk assessment, water monitoring, wetlands*

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INTEGRATING TRADITIONAL IN-SITU ECOLOGICAL SURVEYS WITH LIDAR REMOTE SENSING TECHNIQUES IN HELP FOR DEVELOPING ADAPTATIVE MANAGEMENT STRATEGIES IN CONSERVATION OF WETLAND HABITATS

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Abstract

This study investigates wetland ecosystems through the integration of in situ methodology and LiDAR-based remote sensing techniques. Wetlands are ecosystems vulnerable to climate change, making accurate monitoring of species distribution essential for effective conservation. The main objective of this research is to understand the influence of climate change on species density and spatial patterns, as well as to support the development of well-informed management plans for the administrators of protected natural areas. Field data were collected through direct observations and systematic sampling in order to identify and quantify species presence within the study area. These in situ measurements were complemented by LiDAR scanning and high-resolution photogrammetry, which provided detailed information on vegetation structure, topography, and spatial heterogeneity. The datasets were integrated to generate species density maps and to analyse distribution patterns within the wetland ecosystem. The results show that integrating field observations with LiDAR data significantly improves non-invasive data collection methods, while the spatial resolution of the resulting aerial images enhances the accuracy of species density estimation. In addition, the analysis highlights distinct spatial patterns and variations that may be associated with environmental changes, including the interpenetration of related habitats, as well as changes in hydrological regimes and vegetation structure. These findings emphasize the effectiveness of combining traditional ecological methods with advanced remote sensing technologies for monitoring dynamic wetland ecosystems. The study provides relevant insights into the impact of climate change on biodiversity and constitutes a scientific basis for the development of adaptive management strategies aimed at preserving the integrity of protected ecosystems.

Keywords: *climate change, wetlands, Maramureş, biodiversity, habitats*

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THE EFFECTS OF CLIMATE CHANGE ON WETLANDS WITH A FOCUS ON PEATLANDS

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Abstract

Wetlands are vital ecosystems for the biosphere, but they rank among the most critical and vulnerable ecosystems on Earth. At the same time, wetlands play a major role in climate regulation, carbon storage, and biodiversity conservation because, although they cover approximately 5-8% of the land surface, they store between 20-30% of global carbon, providing essential ecosystem services such as water purification, flood control, and carbon sequestration. Although wetlands influence climate change, they are in turn subject to multiple impacts from it, with rising temperatures, altered hydrological regimes, increased frequency of vegetation fires, and permafrost thaw disrupting natural dynamics. Climate change influences and affects wetlands through several factors, the main ones being: rising temperatures - a phenomenon that accelerates the decomposition of organic matter and increases carbon dioxide and methane emissions; alteration of the hydrological regime - which critically affects wetland functioning, as lowering water levels can transform these ecosystems from carbon sinks into emission sources; and extreme climate events - which affect ecosystem structure and can cause irreversible degradation. Peatlands are among the wetlands most affected by climate change; the aforementioned stressors can push peatlands beyond critical tipping points, transforming them from long-term carbon absorbers into net sources of greenhouse gases, thus creating dangerous positive feedback loops that amplify global warming. Although peatlands cover only 3-4% of the world's land surface, they function as persistent carbon reservoirs, locking up atmospheric carbon dioxide and storing up to one-third of the total global soil carbon - a stock that exceeds that of all other vegetation types combined. In this context, specific peatland processes must be highlighted, such as the transition from the role of "carbon sinks" to sources of greenhouse gas emissions. Climate change generally represents an existential threat to the world's peatlands. Rising temperatures, altered hydrology, permafrost thaw, and increased fire frequency disrupt the fundamental processes that allow these ecosystems to store carbon. The risk of pushing peatlands beyond a tipping point, where they become net sources of greenhouse gases, is real and could trigger a devastating positive feedback loop, accelerating climate change. Prioritizing the conservation of these vital ecosystems is not just an environmental issue, but a critical component of any strategy to achieve global climate stability. The Maramureş region is characterized by hosting oligotrophic, nutrient-poor and transitional peatlands, sensitive to drought and therefore to climate change. Also noteworthy is that the region has a hydrological regime influenced both by precipitation and by karst topography and groundwater tables in depressions. In this context, the climate response of the peatlands in Maramureş is governed by a system of hydrology-determined thresholds, where the depth of the water table mediates the balance between carbon accumulation and loss. While moderate warming may temporarily stimulate peatland growth, drought-induced drying leads to rapid decomposition and potential ecosystem collapse. This paper will analyze the main mechanisms by which climate change affects wetlands and especially peatlands, focusing on the disruption of the carbon cycle, the threat of permafrost thaw, the intensification of

vegetation fires, and the potential for ecosystem tipping points. It will also discuss the critical role of restoration as a mitigation strategy and outline the main adaptation and management measures.

Keywords: *climate change; wetlands; peatlands; carbon; hydrology; ecosystems*

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SPATIO-TEMPORAL ANALYSIS OF WETLANDS UNDER THE IMPACT OF AGGREGATE EXPLOITATION USING MULTISENSOR SATELLITE REMOTE SENSING IN THE MIDDLE COURSE OF THE SOMEȘ, SĂLAJ COUNTY

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Abstract

The paper analyzes the dynamics and evolution of the wetlands associated with the middle course of the Someș River in Sălaj County, with emphasis on the influence of anthropogenic activities, especially the exploitation of sand and gravel carried out in terraces, as well as in the minor and major riverbeds. The study aims to identify, map and evaluate the spatio-temporal changes of these ecosystems, in the context of the interaction between natural processes and human interventions. The methodology is based on the integrated use of Sentinel-1 and Sentinel-2 satellite images, processed in SNAP and QGIS environments, for surface characterization and analysis of wetland dynamics. Spectral indicators were used to highlight vegetation and aquatic surfaces, complemented by radar information on humidity and land structure. The multitemporal analysis has made it possible to detect changes and highlight evolutionary trends, including transformations generated by mineral aggregate mining activities. The results highlight significant changes in the configuration of the riverbed and the hydrological regime, reflected in the appearance, extension or fragmentation of wetlands. The spatio-temporal transformations of wetlands, reflected in the modification of the aquatic surfaces and the structure of the riverbed, overlap entirely over the protected natural areas, highlighting the need for rigorous evaluation and management measures. The study proposes a coherent methodological framework for wetland monitoring, applicable in environmental impact assessment and in substantiating decisions on the sustainable use of natural resources.

Keywords: *wetlands, remote sensing, Sentinel-1, Sentinel-2, NDVI, NDWI, change detection, anthropogenic impact*

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ECOLOGICAL SUCCESSION AND MONITORING OF ARTIFICIAL WETLANDS IN THE SOMEȘ RIVER FLOODPLAIN

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Abstract

Artificial wetlands formed by closed sand and gravel extraction pits offer unique opportunities for ecosystem restoration and biodiversity conservation in river floodplains. The Someș River in Maramureș County features a wide floodplain exceeding 2 kilometers in the Mireșu Mare area, heavily marked by such extraction activities. This study aims to assess the ecological succession and vegetation dynamics of these newly formed wetland landscapes through integrated field mapping and remote sensing techniques. To evaluate the establishment of pioneering species, flora was mapped using both traditional field surveys and advanced monitoring tools. Field observations identified a mixed plant association dominated by key wetland species, including *Phragmites australis*, *Typha latifolia*, *Myriophyllum spicatum*, *Rumex x pratensis* and *Salix triandra*. Aerial mapping was conducted using an Unmanned Aerial Vehicle (DJI Mini 3 Pro) equipped with the Dronelink application, while submerged vegetation height and occurrence were bathymetrically assessed using a Deeper Chirp+ 3 sonar. To monitor spring phenology, vegetation indices such as the Visible Atmospherically Resistant Index and the Green Leaf Index were calculated using the Web Open Drone Map platform at the end of March 2026. The integrated monitoring approach revealed a rapidly flourishing ecosystem characterized by significant seasonal oscillations in the water table, which directly influenced vegetation distribution and density. These findings provide actionable insights for adaptive management, highlighting the successful colonization of both emergent and submerged species and underscoring the ecological value of integrating post-extraction gravel pits into broader floodplain conservation strategies.

Keywords: *artificial wetlands, ecological succession, remote sensing, Someș River, vegetation mapping*

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INTEGRATED GEOSPATIAL DATABASE FRAMEWORK FOR WETLAND MONITORING: COMBINING HIGH-PRECISION UAV DATA AND MULTI-SOURCE ANALYTICS

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Abstract

Wetlands are vital ecosystems that are currently threatened by changes to the hydrological regime and climate change, requiring technologies to monitor them effectively. The article illustrates the integrated Geospatial database architecture developed for the long-term monitoring of international important Carpathian wetlands. A framework for reconciling multi-temporal and multi-source data for environmental modelling and adaptive management was developed. The methodology utilizes a multi-cyclic monitoring approach to capture high-resolution spatial dynamics. The baseline that was established using UAV-based LiDAR acquisition with a DJI Matrice 350 RTK system, while the successive data cycles were completed with other aerial platforms and sensors ensuring temporal continuity. The data processing pipeline incorporated DJI Terra to calibrate LiDAR. Agisoft Metashape and CloudCompare were used to produce and refine the orthomosaics, DEMs, and dense point clouds. This study will have a geospatial database capable of integrating UAV-type data with in-situ hydrological and climatic parameters of different scales. In this centralized system, the data integrity is preserved by applying quality control testing like the homogeneity and outlier test. By integrating high-resolution terrain models into multi-criteria GIS environments within ArcGIS Pro, the spatial accuracy of risk assessments--specifically for flooding, drought, and land degradation--was significantly enhanced. The framework in which high-precision remote sensing and power database management are combined, exhibit efficacy in providing a scientific basis for forecasting and conservation in sensitive wetland ecosystems.

Keywords: *Geospatial database, LiDAR remote sensing, UAV photogrammetry, Wetland monitoring.*

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WETLANDS OF ȚARA MARAMUREȘULUI: TYPOLOGY, FUNCTIONS AND RELEVANCE FOR CONSERVATION

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Abstract

The wetlands of Țara Maramureșului represent some of the most valuable components of the regional landscape due to their typological diversity, their ecological and hydrological role, and their contribution to maintaining natural balance. The study aimed to inventory, classify, and highlight the importance of wetlands in this geographical area in order to outline an overall picture of the main categories of wet habitats and their functions within the Maramureș territorial system. The analysis focused on the hydrographic basins of the Săpânța, Iza, Mara, and Vișeu rivers, as well as on the sector corresponding to the Tisa corridor, where both natural and anthropogenic wetlands, either permanent or temporary, were identified. The typological classification followed the main categories used in the Ramsar system, highlighting permanent and temporary watercourses, freshwater lakes, saline and freshwater marshes, peat bogs, riparian woodlands, springs, subterranean karst systems, as well as human-made forms such as fish ponds, artificial basins, storage reservoirs, salt-extraction areas, and drainage canals. The results revealed a high diversity of these ecosystems and a differentiated spatial distribution, with a significant concentration along the main valleys and in mountainous areas, where features closer to the natural state are still frequently preserved. By contrast, in lowland areas and in the vicinity of settlements, many wetlands have undergone major transformations caused by human intervention, land-use change, and river regulation. The importance of Maramureș wetlands derives from their multiple functions: they provide habitats for numerous plant and animal species, contribute to flood mitigation, facilitate exchanges between surface water and groundwater, filter sediments and nutrients, and support remarkable landscape and ecotourism values. Therefore, understanding the typology and importance of these wetlands provides a necessary basis for coherent conservation, monitoring, and sustainable management measures.

Keywords: *conservation, ecological functions, Maramureș landscape, Ramsar typology, wetlands*

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THE GREAT SWAMP (MLAȘTINA MARE) FROM CAPUL GROȘILOR, A NEW WETLAND IN THE MARAMUREȘ MOUNTAINS NATURAL PARK

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Abstract

This study describes for the first time the Great Swamp from Capul Groșilor, which is made up of two meso-oligotrophic and oligotrophic peat bogs, located next to each other. The swamp is located on the territory of the Maramureș Mountains Natural Park, in the Repedea Valley basin, on the crest of Capul Groșilor mountain, between Râpa Peak (1869 m) and Holovaci Peak (1545 m) in the Pop Ivan massif, Maramureș Mountains, near the state border between Romania and Ukraine, at an altitude of 1514 m, GPS coordinates: 47°55'20.28"N; 24°21'23.70"E. As a result of the research carried out on the two peat bogs, two types of habitats with forest vegetation were identified: south-eastern Carpathian bushes of mountain pine (*Pinus mugo*) in oligotrophic swamps of *Sphagnum* (photo: 1) and rare south-eastern Carpathian common spruce (*Picea abies*) on the peat bogs (photo: 2), which are part of the Natura 2000 Habitat – "91D0* Bog woodlands". In the center of the two wetlands there are two oligotrophic south-eastern Carpathian peat bogs with *Sphagnum magellanicum*, devoid of forest vegetation (photo: 1, 2), with excess water and active peat accumulations, which are part of the Natura 2000 Habitat – "7110* Active raised bogs".



Photo: 1, Habitat of the oligotrophic Southeast Carpathian peat bog with *Sphagnum magellanicum* and the habitat of Southeast Carpathian bushes of mountain pine (*Pinus mugo*) in oligotrophic swamps of *Sphagnum*.



Photo: 3, *Scheuchzeria palustris* L., rare species, glacial relict in the flora of Romania



Photo: 4, Round-leaved sundew (*Drosera rotundifolia* L.), a species of glacial relict in the flora of Romania



Photo: 2, Habitat of the oligotrophic southeastern Carpathian peat bog with *Sphagnum magellenicum* and the habitat of rare southeastern Carpathian common spruce (*Picea abies*) on the bogs.

The floristic composition on these peat bogs is made up of rare species and glacial relicts: sphagnum moss (*Sphagnum* sp.), moss (*Polytrichum* sp.), *Scheuchzeria palustris* L., (Photo: 3) rare species, glacial relict in the flora of Romania, *Round-leaved sundew* (*Drosera rotundifolia* L.), (Photo: 4) glacial relict species in the flora of Romania, black crowberry (*Empetrum nigrum* L. ssp. *nigrum*), glacial relict species in the flora of Romania, small cranberry (*Vaccinium oxycoccos* L.) glacial relict species in the flora of Romania, bilberry (*Vaccinium myrtillus* L.), bog bilberry (*Vaccinium uliginosum* ssp. *uliginosum*), sheathed cottonsedge (*Eriophorum vaginatum* L.), glacial relict species in the flora of Romania, *Carex pauciflora* Lightf, glacial relict species in the flora of Romania, *Carex rostrata* Stokes, *Carex limosa* L., glacial relict species in the flora of Romania, purple moor-grass (*Molinia caerulea* (L.) Moench ssp. *blue*). According to Annex no. 1 of the Habitats Directive (92/43/EEC), these types of habitats are "priority", of community interest, in danger of extinction, for the conservation of which the European Commission, through the Romanian State, assumes a special responsibility for their conservation. In conclusion, the peatland has an area of about 5.1 ha and is one of the largest and most important wetlands in the Maramureş Mountains Natural Park, due to the very rare habitats and the flora with glacial relict species in the flora of Romania.

Keywords: *priority habitats, Maramureş Mountains, glacial relict species, peatlands*

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GEOSPATIAL TECHNIQUES AND WEBGIS APPLICATIONS FOR THE ANALYSIS AND VISUALISATION OF WETLANDS IN MARAMUREȘ LAND

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Abstract

Wetlands are essential components of the landscape, with critical functions in maintaining biodiversity and regulating hydrological regimes. Increasing anthropogenic pressures and environmental change make their monitoring necessary through rigorous scientific methods and modern communication tools. In this context, the study aimed to identify the spatial patterns of wetlands in Maramureș Land using descriptive and inferential statistical methods, while also highlighting the role of WebGIS applications in the visualisation and communication of scientific results. The methodological approach was based on the exploratory analysis of spatial data in a GIS environment, with the aim of identifying distribution patterns, clustering tendencies, and proximity relationships. The analytical component was complemented by the use of WebGIS technologies and interactive multimedia applications designed to enhance the presentation of results through maps and interfaces that facilitate rapid access to relevant information. The results showed that wetlands in Maramureș Land do not display a random distribution, but rather a heterogeneous spatial structure characterized by clustering tendencies and marked territorial disparities. These results revealed clear territorial differences and confirmed the usefulness of the statistical approach for understanding the spatial structure of wetlands. The study emphasizes the value of combining spatial analysis techniques with modern visualisation and communication tools to support wetland monitoring and management, as well as dialogue among the scientific community, local stakeholders, and the general public in a regional and cross-border context.

Keywords: *GIS, Maramureș Land, spatial statistics, WebGIS, wetlands*

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MONITORING OF MOUNTAIN WETLANDS BY FUSING UAV AND LIDAR DATA WITH SATELLITE INFORMATION AND GROUND-BASED DATA, CASE STUDY IEZERUL MARE PEATLAND, MARAMUREȘ MOUNTAINS NATURAL PARK

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Abstract

Among the most valuable existing ecosystems, wetlands must also be included. They are not only sensitive but are even threatened by climate change, various other natural or anthropogenic factors, pollution and change of destination, especially towards agriculture or forest plantations being the main ones. In addition to the fact that wetlands, key ecosystems for biodiversity and fauna, store a third of the carbon in the soil at a global level and regulate hydrology and biodiversity, they contribute significantly to the functioning of mountain landscapes and also represent tourist attractions that require protection and development. A management plan to ensure their integrity and maintenance cannot function without periodically knowing the changes, threats and their effect. This process can be completed by the current, periodic monitoring of the locations covered by the wetlands, action carried out in parallel on three levels, space, by accessing satellite programs, air, through photogrammetric UAV and Lidar surveys and ground through laser scanning and sampling of air, water, soil and vegetation. The fusion process requires a careful approach to combine the strengths of the four data sets. All the information obtained in the previous step is initially processed primarily obtaining the specific products, plans, maps with additional attributes, tables, reports, etc. If we refer only to UAV data, the first step consists of interpolating the two data sets (Photo and LIDAR) at the same spatial resolution, making difference maps essential to identify and correct any systematic errors. Data fusion is recommended to be done by going through the three levels, respectively Low-Level (Raw Data Fusion), Mid-Level (Feature-Level Fusion), High-Level (Decision-Level Fusion) then Core Data Fusion Methods in UAV-LiDAR Systems, obtaining the basic products of processing DSM (Digital Surface Model), DTM (Digital Terrain Model), CHM (Canopy Height Model). All studies that have addressed the topic of territorial data fusion, in general and for wetlands in particular, conclude that by fusing this information, they complement and validate each other, the result being clearly superior to any sequential data analysis. In the case of mountain wetlands, this interaction of information from multiple sources allows not only a better understanding of their current state, but also an efficient monitoring of their dynamics over time, essential for conservation and restoration efforts. By integrating data from different satellite programs, Photogrammetric UAV and Li-DAR systems, and terrestrial data into a unified system, mountain wetlands create an information base that allows for their efficient monitoring, allowing for rapid intervention and long-term ecosystem resilience.

Keywords: *Satellite Programs; Photogrammetric UAV and Lidar surveys; wetland ecosystems; DSM; DTM; CHM*

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MONITORING OF WATER QUALITY IN THE SYNEVYR LAKE BASIN SYSTEM: HISTORY, DEVELOPMENT, AND PROSPECTS

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Abstract

The wetlands of the Ukrainian Carpathians perform crucially important ecosystem functions, yet their condition is increasingly dependent on climate change, human impact, and inadequate management practices. Lake Synevyr is the largest lake in the mid-mountain region of the Ukrainian Carpathians and serves as a strategic reference point for regional monitoring and biodiversity conservation. The aim of the study was to identify key indicators for the systematic monitoring of water quality in Lake Synevyr and to justify their integration into sustainable development programs. To achieve this goal, a comprehensive approach was applied, including field measurements of physical parameters (temperature, transparency, seasonal water level fluctuations) and hydrochemical indicators (dissolved oxygen, pH, mineralization, nitrogen and phosphate compounds, heavy metals). The research was conducted within the lake-basin system using route surveys and laboratory analysis of water samples. The results showed that a combination of hydrochemical and physical-geographical indicators is most informative for assessing the state of the ecosystem. Identifying seasonal variability in hydrochemical water quality parameters, which correlate with recreational pressure and hydrological conditions, will contribute to a comprehensive solution for preserving the ecological state of the Synevyr lake-basin system. The data obtained have practical significance for sustainable water resource management: they allow for the timely identification of ecological risks, the regulation of recreational pressure, and the integration of monitoring results into regional and national sustainable development programs. This creates a foundation for the development of long-term strategies to preserve Lake Synevyr as a natural and cultural symbol of the Ukrainian Carpathians. Thus, the study demonstrated the value of systematic monitoring that combines physical and hydrochemical indicators and confirmed its role as a tool for adaptive management of wetlands.

Keywords: *Lake Synevyr, water quality monitoring, hydrochemical indicators, environmental risks, sustainable development.*

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ASSESSMENT OF ANTHROPOGENIC IMPACT ON LAKE SYNEVYR BASED ON HYDROCHEMICAL WATER QUALITY INDICATORS

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Abstract

Lake Synevyr, located within the Synevyr National Nature Park (Khust district, Zakarpattia region), is considered one of the most valuable natural gems of the region and is recognized as one of the natural wonders of Ukraine. Under modern conditions, the areas surrounding the lake are активно used not only for tourism but also for recreation, which leads to increased anthropogenic pressure on the lake ecosystem. In this regard, an important component of assessing such impact is the analysis of the hydrochemical parameters of the water of Lake Synevyr. Since the lake is fed by three tributaries and has one outflow, it is advisable to study water quality at different points within the lake-basin system. The aim of this study was to determine the hydrochemical characteristics of the water of Lake Synevyr and its feeding sources in order to assess the level of anthropogenic impact on the reservoir. Sampling and preservation of water samples were carried out in accordance with current standards (DSTU ISO 5667-1-2003, DSTU ISO 5667-2-2002, DSTU ISO 5667-3-2001). Sampling points were selected taking into account the need to cover the hydrochemical characteristics of the tributaries of Lake Synevyr, the lake water itself, as well as the water of its outflow. To assess water quality, a set of indicators was used, including: pH (DSTU 4077-2001), chloride content (DSTU ISO 9297:2007), sulfates (DSTU ISO 15923-1:2018), hydrogencarbonates (DSTU ISO 9963-2:2007), magnesium and calcium ions (DSTU ISO 6059:2003, DSTU ISO 6058:2003), biochemical oxygen demand (BOD₅) (DSTU ISO 5815-2:2009), sodium ions (DSTU ISO 11885:2005), nitrates (DSTU 4078-2001), nitrites (DSTU ISO 6777:2003), and ammonium ions (DSTU ISO 7150-1:2003). The obtained experimental data indicate that, for most hydrochemical parameters, the water of Lake Synevyr meets established standards, although some indicators show minor deviations. In summary, the results of the study suggest that the hydrochemical state of the lake water and its tributaries is characterized by relative stability of most parameters.

Keywords: *Lake Synevyr, hydrochemical parameters, water quality assessment, anthropogenic impact, wetland monitoring.*

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INTEGRATION OF OPEN SATELLITE DATA AND HYDROMETEOROLOGICAL OBSERVATIONS FOR MONITORING WETLAND ECOSYSTEMS: THE CASE OF LAKE SYNEVYR (UKRAINIAN CARPATHIANS)

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Abstract

Wetland ecosystems are highly dynamic and sensitive to both climate variability and anthropogenic pressure, requiring the development of integrated and continuous monitoring approaches. This study presents a framework for monitoring the wetland ecosystem of Lake Synevyr (Ukrainian Carpathians) based on the integration of open-access satellite data from the Copernicus program and in-situ observations provided by the Ukrainian Hydrometeorological Center. The proposed approach combines multi-source datasets to assess key components of the wetland system, including hydrological dynamics, water quality, and vegetation changes. It has been applied to assess the winter condition of the Lake Synevyr Wetland of International Importance. Optimal thresholds for distinguishing between water, snow, wet snow, and ice were determined using Sentinel-2 (S2/MSI) satellite data. These thresholds are most effective in the short-wave infrared (SWIR) and near-infrared (NIR) bands. These datasets are supplemented by hydrometeorological measurements, including water level, air and water temperature, precipitation, and snow cover, which are essential for the calibration, validation, and interpretation of remote sensing products. This has enabled the determination of the periodicity of changes in the winter conditions of the "Lake Synevyr" wetland. The integration of these datasets has enabled the development of harmonized time series (from 2022 to the present) and supports the analysis of seasonal and interannual variability. Particular attention is paid to the relationship between temperature regimes, snow cover conditions, and the lake's ice conditions. This framework also allows for the identification of signs of climate change and trends in these changes. The results show that combining open Earth observation data with ground-based measurements significantly improves the accuracy and temporal resolution of environmental assessments. This approach provides a reliable foundation for evidence-based management of protected areas. The proposed approach can be applied to other wetland ecosystems in the Carpathian region and beyond, contributing to the development of scalable and cost-effective environmental monitoring systems.

Keywords: *wetland monitoring; lake Synevyr; Sentinel-2; remote sensing; hydrological dynamics; snow and ice conditions; time series analysis; climate variability; Copernicus data; protected areas management.*

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SNOW SURVEYS WITHIN THE GEOECOLOGICAL MONITORING SYSTEM OF WETLANDS: A CASE STUDY OF SYNEVYR LAKE

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Abstract

Mountain wetlands are sensitive to climate change, alterations in the hydrological regime, and increasing anthropogenic pressure, and therefore require systematic geocological monitoring, an important component of which is the study of snow cover as a source of seasonal water accumulation. The aim of this study was to substantiate the role of snow surveys in the geocological monitoring system of wetlands, using the lake-basin system of Lake Synevyr in the Ukrainian Carpathians as a case study. Snow surveys were conducted during the winter period of 2025-2026 within the 2.32 square kilometre catchment of Lake Synevyr along a route extending from the lake toward Mount Ozerna, whose elevation reaches 1495.9 metres. Instrumental investigations of snow cover were carried out using a weighing snow gauge, which made it possible to determine snow depth, snow density, and snow water equivalent within representative altitudinal zones of the catchment. The spatial organization of snow cover was assessed with regard to the altitudinal gradient and the landscape structure of the area. At eight snow survey points, snow depth, density, structure, and snow water storage were determined during the period of peak snow accumulation. The results made it possible to identify the altitudinal differentiation of snow cover within the catchment and to assess the spatial features of its snow water equivalent. It was found that, within the altitudinal zones of the catchment, the average snow cover depth ranged from 32.2 to 56.3 centimetres, while snow water storage ranged from 77.28 to 146.38 millimetres. The highest values were recorded in the middle-mountain part of the catchment at elevations from 1225 to 1275 metres, whereas lower values were observed at both lower and higher elevation intervals. This distribution pattern indicates a complex spatial organization of snow cover under the influence of landscape conditions, elevation, microclimatic features, and the properties of the underlying surface. The obtained data are important for assessing the seasonal water supply of the lake-basin system, forecasting spring runoff, and identifying the geocological features of the functioning of mountain wetlands. The study confirms that snow surveys are an effective field tool for geocological monitoring and can be used to provide a scientific basis for the conservation and sustainable management of such natural systems.

Keywords: *geocological monitoring, Lake Synevyr, snow cover, snow surveys, wetlands*

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FEATURES OF THE APPLICATION OF AIRBORNE LASER SCANNING METHODS FOR MONITORING THE TERRITORY OF THE LAKE SYNEVYR WETLAND

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Abstract

Wetlands of the Ukrainian Carpathians perform important ecosystem functions, but their condition increasingly depends on climate change, anthropogenic pressure and the effectiveness of natural resource management. The aim of the study is to substantiate the use of airborne laser scanning methods in the system of comprehensive monitoring of the wetland of Lake Synevyr in combination with traditional observation approaches. To achieve this goal, an approach was used that involves the integration of remote sensing data with field indicators. The use of airborne laser scanning allows obtaining high-precision spatial information about the relief and coastal zone, determining the water surface level and its seasonal variability, as well as monitoring the development of landslide processes and other dangerous geomorphological phenomena characteristic of mountainous areas. In addition, lidar data provide the ability to analyze the structure, density and dynamics of vegetation cover in the coastal zone of the lake. The results of the study showed that the integration of lidar data with hydrophysical and hydrochemical indicators significantly increases the informativeness of the assessment of the state of the wetland. It was established that the effectiveness of the use of aerolaser scanning depends on compliance with regulatory requirements for accuracy, which in national practice are mainly regulated through root-mean-square errors, while the density of the point cloud remains insufficiently formalized. This necessitates the coordination of data accuracy and density parameters to ensure reproducibility of the results. The obtained data are of practical importance for comprehensive monitoring of the wetland: they allow for accurate determination of water level, timely detection of landslide processes and analysis of the state and dynamics of vegetation. Their integration with other indicators contributes to a more complete understanding of the functioning of the ecosystem and increases the effectiveness of management decisions. Thus, the study confirms the feasibility of using airborne laser scanning as an integral component of systematic monitoring that combines spatial and physical indicators, and emphasizes its role as an effective tool for comprehensive assessment and adaptive management of wetlands.

Keywords: *Lake Synevyr, wetlands, complex monitoring, LiDAR, airborne laser scanning, water level, landslide monitoring, vegetation analysis, digital terrain model, environmental monitoring.*

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HYDROGEOLOGICAL ASSESSMENT OF WATER INFILTRATIONS AND THEIR IMPACT ON THE GEOMECHANICAL STABILITY OF ROCK SALT EXCAVATIONS AT THE TÂRGU OCNA SALT MINE, TROTUȘ MINE, ROMANIA

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Abstract

The exploitation of the gem salt from the Targu Ocna Salt Mine, Trotuș Mine, Romania, due to the mining voids created, the initial stability of the massif was destroyed, the hydrogeological conditions of the deposit were gradually modified. The sterile intercalations, especially clayey, which acted as a protective shield against water infiltration, being cracked or broken, opened the possibility of water infiltration through the stratification planes, faults, fissures and cracks. The water coming from the condensation on the ceiling, walls and hearth of the mining works produced superficial dissolution phenomena. After drying, the solidified salt remained on the surfaces of the ceiling, walls or hearth of the excavated spaces. The most illustrative area in this regard is the entrance from the car plan to the V horizon of the Trotuș Mine, where the hearth and the ceiling of the rooms are covered with recrystallized salt. On 17.10.2024, when a visit was made underground, before the entrance gate and then approx. 100 meters, at the hearth of the room there were numerous puddles, with a depth of 5-10 cm. The presence of water in the salt massif generated dissolution phenomena, which affected the bearing capacity of the resistance elements, pillars and floors, in two ways, namely the reduction of the values of the mechanical resistances over time and the reduction of the dimensions of the resistance elements, due to the dissolutions. The limitation of the phenomena of infiltration of water into the groundwater can be achieved, in the first instance, by carrying out, on the surface, some water capture and drainage work, apart from the cones of collapse of the old basins. In this regard, guard channels, gutters, ditches, or regularization works of the riverbeds of the Trifu and Grebleș streams that cross the exploitation perimeter can be built. In order to monitor the stability of the land surface in the salt mining perimeter, in addition to the topographic landmarks, located on the area adjacent to the perimeter, continuous monitoring of the morphology of the land was introduced, through aerial photogrammetry from drones. This method allows the construction of continuous, high-precision three-dimensional digital models of the land surface of the entire mining perimeter.

Keywords: *salt, underground, instability, infiltrations, monitoring program, etc.*

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ASSESSMENT OF THE HYDROLOGICAL IMPACT ON SLOPE STABILITY: A MULTI-SENSORY ANALYSIS BY GEODESIC, TOPOGRAPHIC, PHOTOGRAMMETRIC, LIDAR METHODS OF A LANDSLIDE

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Abstract

Landslides are complex geodynamic processes triggered by the breakdown of the balance between active gravitational forces and the shear strength of the earth massif. This instability is often the result of the interaction between intrinsic geological factors and external triggers (precipitation, thermal variations, anthropogenic activities). The causal factors of landslides vary in their action over time and it should be emphasized that the influence of different factors (agents) on the equilibrium state of the slopes is exerted in a combined and not isolated way. Most of the natural mechanical factors that lead to landslides are directly dependent on the presence of surface water and groundwater. The surface waters exert a permanent erosion action of the banks and the base of the slopes. The phenomenon leads to a decrease in the resistance forces, which determines the reduction of the slope's stability until the equilibrium phase, the limit at which the landslide occurs. The action of groundwater on the land is manifested by the water pressure in the pores, the filtration pressure and the suffocation process, to which are added the change in time of the physical-mechanical properties, the reduction of the mineralization of the water in the pores and the negative effect of the rise of the groundwater level. The study demonstrates that the multi-sensor and multi-temporal approach through topographic, photogrammetric and LiDAR methods is a robust solution for monitoring landslides, offering a high level of accuracy, detail and repeatability. In the case of the landslide in the premises of CMID Dobrin, Sălaj County, the analysis highlighted an active instability of moderate intensity, controllable by appropriate technical measures and by maintaining a systematic geospatial monitoring program. The methodological approach, which combined high-precision point measurements (total station, static GNSS systems) with extended coverage measurements (UAV photogrammetry and LiDAR), proved to be highly effective. Digital elevation (DEM), surface (DSM) and terrain (DTM) models derived from LiDAR data allowed for the identification and detailed mapping of the microrelief specific to instabilities, including tensile cracks, slip steps, microdepressions and areas of displaced material accumulation. This information is crucial for the precise delimitation of risk areas and for the design of interventions. The study reconfirmed the fundamental role of hydrological factors in accelerating instability processes. Water infiltration, facilitated by the extensive crack system and the degradation of the collection ditches, lead to an increase in pore pressures and a reduction in the shear strength of clay materials. This complex interaction between natural (geology, geomorphology,

hydrology) and anthropogenic (slope changes, infrastructure) factors underlines the need for a holistic approach to risk management.

Keywords: *sistem GNSS, landslides, LiDAR, infiltrations, monitoring program, etc.*

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GIS MODELING OF HYDROLOGICAL DYNAMICS ON CLOSED MINING AREAS

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Abstract

The closure of coal mines generates numerous environmental problems, including the accumulation and circulation of water in the affected perimeters. Problems with water drainage on the surface of disused coal mines generally develop when groundwater and surface water enter the exploited areas and come into contact with primary and secondary minerals under oxide conditions. During contact with these minerals, water can dissolve the components of the ore and minerals that make up the rock. This paper investigates the use of GIS technologies to simulate the hydrological modeling of surface water on a former coal mine, in order to understand the processes of drainage, accumulation and their impact on the environment. By mapping areas with UAV technology, integrating climate and geological data into digital terrain models (DTMs) and using hydrological algorithms, the study evaluates runoff directions, accumulation areas and risks associated with water contamination. The results obtained contribute to a better management of these areas and to the implementation of sustainable solutions for the restoration of ecosystems affected by mining activities. The purpose of this work is the scientific study of a simulation of the formation of the hydrographic network exposed to the climatic factors constantly existing in the environment, created on the surface of a land of a former exploitation mine, by collecting data on the topography of the land. A mining operation is a site where mineral resources are extracted from the earth's subsoil. The hydrological study of an area has an applicability in the management of water resources because by understanding the way water circulates on a certain surface, we can efficiently manage water resources. This includes assessing the amount of water available, identifying water sources and establishing the necessary measures for its conservation and sustainable use, and analysing the water runoff regime through which flood-prone areas can be identified.

Keywords: *coal mine, GIS, UAV, digital modeling, hydrology, environment, etc.*

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GEOSPATIAL DATA ACQUISITION AND DATABASE STRUCTURING FOR UTILITY NETWORK CADASTRE IN AN URBAN AREA

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Abstract

This paper presents a technical workflow for developing a cadastral information system for urban utility networks in the Gheorgheni district of Cluj-Napoca, Romania. The study targets four network classes - water supply, sewerage, natural gas, and electric power - and focuses on the integration of field surveying, spatial database structuring, and thematic mapping in a single operational framework. Spatial data acquisition was carried out using GNSS observations, total station measurements, and the combined traverse-radiation method to determine the planimetric and altimetric position of visible utility elements and related technical features. The processing stage included coordinate computation, drafting of technical-edilital plans, creation of thematic layers, topology building, centroid generation, and attachment of descriptive attributes in AutoCAD Map 3D. The proposed data model links geometric entities with technical attributes such as material, diameter, number of service connections, inspection-related information, and network-specific operational characteristics. In addition, external databases were connected to the mapped entities to enable bidirectional queries between cartographic objects and tabular records. The resulting prototype supports fast retrieval, visualization, and thematic interrogation of utility-network information and can assist maintenance planning, infrastructure coordination, and urban management. The case study indicates that integrating geodetic measurements with GIS-based cadastral data structures improves data consistency, traceability, and update capacity, while providing a scalable basis for future 3D utility modelling and digital urban-infrastructure management.

Keywords: *cadastral information system, GIS, GNSS surveying, thematic mapping, urban utility networks, utility cadastre*

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LAND USE PLANNING AND LANDSLIDE RISK MITIGATION THROUGH THE INTEGRATION OF 3D CADASTRE AND UNDERGROUND INFRASTRUCTURE

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Abstract

Urban planning in landslide-prone areas requires the integration of geotechnical factors, land administration systems and the increasing complexity of underground structures. The rapid vertical and subsurface expansion of urban environments, including transport tunnels, utility networks and underground facilities, introduces significant challenges for land use planning, particularly in unstable slope areas. Ground excavations, modifications of drainage systems and additional structural loads may either trigger or stabilize landslides, highlighting the need for integrated planning tools that consider both risk and legal constraints. This study proposes a conceptual and methodological framework aimed at ensuring consistency between landslide risk assessment, spatial planning and land administration processes. The approach integrates three key components: geotechnical and geomorphological data used in 3D/4D landslide modelling; a 3D cadastre system representing property rights, restrictions and responsibilities in volumetric space; and the mapping of underground infrastructure as both exposed elements and planning constraints. The methodology is based on the analysis of international best practices in countries with advanced 3D cadastre and subsurface management systems. It introduces an interoperable GIS-BIM-CityGML workflow that integrates spatial, infrastructural and cadastral data using standardized models. The framework also defines the minimum required dataset and essential geometric and legal attributes necessary for cadastral objects, supporting zoning regulations and planning restrictions in landslide-affected areas. The results demonstrate that the integration of 3D cadastre with geotechnical risk assessment and underground infrastructure modelling enhances the accuracy of property documentation, reduces spatial conflicts and supports transparent decision-making processes. Furthermore, volumetric representation of land parcels and subsurface structures enables more detailed analysis and improved management of landslide risks. Overall, the proposed approach contributes to sustainable urban development by supporting risk-informed planning and increasing resilience in dynamically evolving geological environments.

Keywords: *3D cadastre, GIS-BIM integration, land use planning, landslides, subsurface infrastructure*

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INCREASING THE ENVIRONMENTAL MONITORING CAPACITY OF AREAS OF FORMER MINING EXPLOITATIONS IN NORTHWESTERN ROMANIA BY DESIGNING AN INTEGRATED MONITORING MODEL IMPLEMENTED ON A GIS PLATFORM

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Abstract

The closure of mines in northwestern Romania has brought a series of problems regarding the long-term effects of mining on the environment, problems that remain unresolved. The main environmental effects of mining have been reflected on the lands above or near former underground mining sites. This paper analyzes the opportunity and possibility of increasing environmental monitoring capacity in former mining areas in Northwestern Romania, by designing an integrated monitoring model implemented on a GIS software platform. The general objective of the paper is to propose an integrated model for increasing environmental monitoring capacity in former mining areas in northwestern Romania by reducing degradation and disaster risk, improving the environment through an active integrated monitoring system. The research addresses in an integrated manner the main phenomena specific to these areas: the effects of underground voids on the surface (subsidence, degradation of the natural and built environment), residual pollution of environmental factors (soil, subsoil, water, air), and the impact of climate change. Phenomena such as the effects of underground voids on the surface (subsidence, degradation of soil, vegetation, buildings, and communication routes), analysis of residual pollution (subsoil, soil, air, water), and the effects of climate change on areas affected by mining activity are studied. The research methodology combines classical techniques (total topographic stations, sampling) with modern technologies (GPS, interferometry, videography, laser scanners, remote sensing) and continuous monitoring of environmental parameters, for a complex spatio-temporal analysis. A central element of the project is the integration of all data into a dynamic GIS database, structured into thematic layers and supported by specialized software platforms (e.g., ArcView/ESRI) and permanent updating, constituting an active GIS platform. The software component includes the creation of a mining database, establishing the structure and management system, implementing monitoring software on the GIS platform, loading data, and forming the GIS Mining Data Bank. The system allows continuous data updating, identification of critical areas, placement of monitoring stations, and real-time risk assessment. Furthermore, the project includes the development of an online platform for interdisciplinary collaboration and dissemination of results. The paper raises an alarm regarding the lack of concern in determining the danger posed by former underground mines in Maramureş County, concerning surface movements and pollution. By implementing this technical-managerial model, the project contributes to substantiating decisions regarding the sustainable management of affected mining areas and increasing their resilience to natural and anthropogenic hazards.

Keywords: *Environmental monitoring, GIS integration, Subsidence, Residual pollution, Climate change, Mining hazards, Risk assessment.*

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GENERAL MONITORING USING GEOMATIC TECHNOLOGIES OF SALT MINES UNDER THE INFLUENCE OF NATURAL ENVIRONMENTAL AND ANTHROPOGENIC FACTORS: A LITERATURE REVIEW AND BIBLIOMETRIC ANALYSIS

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Abstract

Although salt mines are considered relatively more stable compared to other types of mines, they present specific risks related to the interaction of infiltrating water with salt, salt dissolution, and its deformation over time, which can affect both the mine and the environment over very large areas through watercourses. Salt mines are underground excavations with special characteristics, different from those of coal or metal ore mines. In addition to the destructive effects caused by the contact between water and salt, these mines also exhibit high structural instability and subsidence phenomena, partly due to the properties of salt. Monitoring the preservation of the structural integrity of salt mines, demanded by a series of environmental factors, others due to exploitation, and yet others of anthropogenic nature, is essential for safety and maintenance under these conditions. In this case, as in the monitoring of structures and land, numerous studies employ various theories, methodologies, and technologies that have advanced rapidly due to the expansion of information technology. The objective of this study is to identify areas where research is deficient or even absent in the existing literature regarding the cause-effect relationships established between stress factors, the effects produced on the mine, and their propagation to the surrounding environment, along with the analysis of techniques and technologies used for their monitoring. To achieve this objective, the most critical factors found to influence and affect salt mines and then the propagation of the produced effects to the environment, focusing on those that cause changes in the geometry of the Earth's surface, the technologies used for their monitoring, and the analysis of development trends in the field have been identified through a systematic search in the most popular databases, namely Scopus and WoS MJL by Clarivate. Following an extensive analysis of the current state of the field in the specialized literature, especially that published by the most prestigious journals in the field, the study was able to further employ a bibliometric analysis, carried out using VOSViewer 1.6.20 and CiteSpace software, exploring the challenges and prospective research areas reflected in the literature and the relationships created between them. The findings indicate a lack of scientific investigations on environmental factors influencing the Structural Health Monitoring (SHM) of Very Tall and Slender Structures, particularly studies on the effect of non-uniform sunlight on structures. The research provides a comprehensive understanding of the current state of the analyzed field and the research trends under consideration, allowing further research to build upon this knowledge.

Keywords: *Salt mines, Geomatics monitoring, Total stations, TLS, UAV, Remote sensing, Sensors, Ground monitoring, Subsidence, Collapses, Flooding*

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THE CONSEQUENCES OF INSUFFICIENT STUDY OF A SITE OBTAINED BY DRAINING A SWAMPY AREA

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Abstract

Over time, people have sought to improve land affected by water accumulations and transform it into cultivable land, or even suitable for building construction.

The behavior of a construction over time is greatly influenced by the nature of the foundation soil. In the case where the land on which the construction is to be located resulted from drainage and desiccation works of a marshy area, it is necessary to carry out geological and geotechnical studies, through which data on the nature of the foundation soil can be obtained. The design for the future construction will be based on the conclusions of these studies, and the proposed constructive solution and its implementation methods will have to take into account the situation on the ground and the way in which any risk factors identified by the studies carried out may have a disruptive influence on the functionality of the building in question.

There are cases when, despite the fact that the adopted constructive solutions are consistent with the conclusions of the preliminary studies, due to inappropriate approaches in carrying out these studies, over time, deformations appear in the structure of the buildings, which affect their exploitation.

This paper presents the situation of a production hall located on a land obtained by draining a marshy area and filling the resulting voids with waste from construction works, having a superficial layer of productive soil on the upper part. Later, part of the land was concessioned for the construction of the construction in question.

After commissioning, the hall floor was affected by the appearance of areas with differentiated settlements, which led to the start of a monitoring program using geodetic methods. The information obtained showed not only that the process of differential settlement was not only manifested in the case of the floor, but also in the case of a number of thirteen columns in the resistance structure, but also highlighted a dependence between the settlement value per observation cycle and climatic conditions (humidity and temperature).

Keywords: *desiccation, geodetic methods, monitoring, settlement-humidity dependence*

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APPLYING THE ANALYTIC HIERARCHY PROCESS TO DETERMINE STAKEHOLDER NEEDS AND PRIORITIES FOR WETLAND PROTECTION IN THE CARPATHIAN REGION

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Abstract

Wetlands in the Carpathian region provide critical ecosystem services, including water purification, flood regulation, carbon sequestration, biodiversity conservation, support for local livelihoods and cultural practices. Despite their ecological and socio-economic importance, these ecosystems face increasing pressures from agricultural expansion, infrastructure development, pollution, and climate change. Moreover, limited financial and institutional resources for conservation require systematic prioritization among competing needs and diverse stakeholder perspectives. This study applied the Analytic Hierarchy Process (AHP) to identify and prioritize the needs and objectives of seven key stakeholder groups involved in wetland protection across the Carpathian region, specifically in Romania, Ukraine, and Slovakia. Drawing on empirical data from 87 stakeholders, the research developed a hierarchical decision framework comprising six evaluation criteria: Ecological Value, Threat Severity, Action Effectiveness, Stakeholder Challenges, Resource Needs, and Collaboration Level—derived directly from survey instruments. The framework integrates perspectives from local communities, farmers and landowners, tourism operators, environmental NGOs, government bodies, scientific researchers, and international conservation organizations. Results demonstrate that Ecological Value (35.7%) and Threat Severity (22.5%) emerge as the highest-weighted criteria, indicating strong stakeholder consensus on the primacy of biodiversity and urgent threats. Among stakeholder groups, NGOs (0.198), Local Communities (0.184), and Research institutions (0.156) rank as the highest priority, while Business stakeholders rank lowest (0.082). Consistency analysis confirms judgment reliability, with all Consistency Ratios below 0.10. Sensitivity analysis reveals that NGO leadership remains robust across alternative weighting scenarios. The findings reveal both points of consensus—particularly regarding ecological priorities and community challenges—and areas of conflict, especially concerning the role of business interests and resource allocation mechanisms. This research contributes to Carpathian wetland management by providing a transparent, participatory, and mathematically rigorous basis for resource allocation and conflict resolution. More broadly, it advances the application of multi-criteria decision analysis in environmental conservation, demonstrating how structured methodologies can integrate diverse knowledge systems and value judgments to support equitable and effective conservation outcomes.

Keywords: *Analytic Hierarchy Process; Carpathian region; ecosystem services; multi-criteria decision analysis; participatory environmental management; stakeholder analysis; wetland conservation;*

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FROM PERSONAL ENGAGEMENT TO CO-MANAGEMENT: REFRAMING WETLAND GOVERNANCE THROUGH EDUCATION AND CITIZEN SCIENCE

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Abstract

Wetland governance continues to be dominated by top-down management approaches that often limit meaningful stakeholder participation and fail to fully integrate local knowledge into decision-making processes. Although citizen science and stakeholder engagement have gained increasing attention as tools for participatory environmental governance, the mechanisms through which individual motivation translates into collective action remain insufficiently conceptualized. This paper proposes a conceptual model that introduces *personal engagement* as a critical intermediary stage between education and active participation in wetland governance. The model outlines a five-stage pathway: awareness, personal engagement, citizen science participation, deliberation, and co-management. In this framework, education acts as a cross-cutting catalyst that fosters ecological literacy and supports the development of personal engagement, understood as the psychological and motivational readiness of individuals to become actively involved in environmental issues. Personal engagement is positioned as the key transition point where awareness is transformed into active willingness to participate, enabling individuals to engage in citizen science activities and contribute to knowledge co-production. Through deliberative processes, this engagement is further expanded into collective stakeholder interaction, ultimately supporting the emergence of co-management arrangements. By linking education, personal engagement, citizen science, and governance processes within a unified framework, the paper reframes wetland governance as a dynamic continuum from individual motivation to institutional collaboration. The proposed model contributes to theoretical discussions on participatory governance and offers a foundation for future empirical validation and policy development in wetland management.

Keywords: *personal engagement, education, citizen science, wetland*

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WETLANDS IN THE CONTEXT OF BIODIVERSITY CONSERVATION IN MARAMUREȘ

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Abstract

In the general context of nature conservation in Maramureș, wetlands have a special role because of their rich biodiversity and their vulnerability. The paper presents the patterns of protected area designation and management in the past, the situation today and the opportunities and challenges for the future. Quality and quantity of data regarding biodiversity in general and wetland biodiversity in special is presented – also the difficulties to have relevant data from the fields, in the context of financial limitations, availability of experts and administrative/ legal burdens for implementing research. We are taking into consideration the scientific bases for decision-making in protected area designation, creation of management plans, public involvement in nature protection, and the role of protected areas as places for field research, ecotourism and ecological education. We are discussing the necessity of a long term ecological research (LTER) plan for the protected areas of Maramureș and a need to develop a functional citizen science program for the area. Conclusion: wetland research, monitoring, conservation should be an important part of the biodiversity conservation agenda in Maramureș, an integrated approach involving scientists, researchers, nature conservation practitioners, protected area managers, NGO/ civil society representatives, universities and key persons from various parts of the society, from artists to politicians – developing also international contacts, cooperation and relevance.

Keywords: *biodiversity, citizen science, LTER, Maramureș*

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THE ROLE OF MODULAR CONSTRUCTIONS IN NATURE OBSERVATION FOR ENHANCING WETLAND TOURISM POTENTIAL: A CASE STUDY OF IEZERUL MARE PEAT BOG, DESEȘTI MARAMUREȘ

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Abstract

Wetlands, especially active peatlands (EU priority habitat code 7110), are ecosystems extremely sensitive to anthropogenic interventions, yet simultaneously of great tourist attraction. Iezerul Mare peat bog in Desești, Maramureș, is an oligotrophic peat bog with excellent conservation status, hosting rare species. However, the absence of visitor infrastructure leads to uncontrolled trampling and irreversible peat compaction. Paradoxically, the very fragility of the ecosystem demands innovative construction solutions that allow nature observation without compromising ecological integrity. Modular constructions offer an appropriate architectural response to this challenge. By prefabricating components off-site and assembling them in situ with light machinery, they significantly reduce pollution, construction time, and soil footprint. The study comparatively analyzes six international projects of towers and bird observatories located in sensitive wetlands (Abu Dhabi, Netherlands, China). All utilize reversible foundations (helical piles), sustainable materials (thermally treated wood, recycled plastic, local reed), and visual and acoustic camouflage strategies to avoid disturbing wildlife. Based on these best practices, the paper proposes a conceptual framework for a modular observatory at Iezerul Mare: a cross-laminated timber structure, 8–12 meters high, with an easy access ramp (8% slope), located in the buffer zone of the reserve, at least 50 m from the central water body. Stepped platforms allow differentiated observation of peatland flora, birds, and the mountain landscape. Expected benefits include non-intrusive scientific monitoring, environmental education, and the development of sustainable tourism that generates income for the local community without damaging the priority habitat. The modular, reversible, and climate-change-adaptable solution can become a national best-practice model for the sustainable valorization of protected wetlands.

Keywords: *modular constructions, wetlands, ecotourism, peat bogs, bird observation, Maramureș, priority habitat*

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THE FINANCIAL ROLE OF BLOCKCHAIN IN THE MAINTENANCE AND PROTECTION OF WETLANDS

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Abstract

Wetlands rank among the most biologically productive and economically valuable ecosystems on Earth, providing critical services including flood regulation, water purification, carbon sequestration, and biodiversity habitat. Despite their importance, wetlands are disappearing at an accelerated rate—three times faster than forests—driven by agricultural conversion, infrastructure development, and climate change. The global wetland finance gap remains substantial, as traditional funding mechanisms such as government grants, development aid, and philanthropic contributions consistently fall short of the resources required for effective conservation and large-scale restoration. This paper examines the emerging role of blockchain technology in addressing this financial shortfall. Blockchain offers three transformative financial applications tailored to wetland conservation. First, the tokenization of environmental assets—including carbon credits, biodiversity credits, and water quality credits—converts ecological metrics into tradeable digital instruments, enabling fractional ownership and global market access. Second, smart contract automation facilitates transparent, verifiable payments for ecosystem services (PES), releasing funds automatically upon independent verification of conservation outcomes (e.g., restored hydrology or revegetation targets). Third, decentralized financing mechanisms, including decentralized autonomous organizations (DAOs) and peer-to-peer lending protocols, reduce intermediation costs and unlock new sources of private capital from impact investors and retail participants. Key findings indicate that blockchain-enabled wetland finance can enhance transparency through immutable transaction ledgers, improve accountability with tamper-proof audit trails, reduce transaction costs by an estimated 30–40% through automated verification and disintermediation, and unlock new funding streams via globally accessible tokenized assets. However, significant challenges remain. These include high initial implementation costs, steep stakeholder learning curves across conservation and finance sectors, regulatory uncertainty regarding the legal status of tokenized environmental assets, and the risk that energy-intensive proof-of-work blockchains could undermine conservation goals. The latter can be mitigated by adopting proof-of-stake or other low-energy distributed ledger technologies. The paper concludes with actionable recommendations for policymakers, conservation practitioners, and financiers to responsibly integrate blockchain into wetland finance strategies while mitigating associated risks, including piloting regulatory sandboxes, investing in digital literacy, and mandating low-energy blockchain protocols.

Keywords: *Wetland conservation; blockchain technology; tokenization; carbon credits; biodiversity credits; payments for ecosystem services (PES); smart contracts; decentralized finance (DeFi); environmental finance; green fintech; nature-based solutions; climate finance*

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THE ROLE OF CULTURAL INSTITUTIONS IN ENHANCING COMMUNITY ENGAGEMENT FOR WETLAND CONSERVATION

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Abstract

Wetlands provide vital ecosystem services, including biodiversity support, water regulation, and climate mitigation, yet they are increasingly threatened by land-use change, urban expansion, pollution, and limited public awareness. While scientific, technical, and economic approaches to wetland management are well developed, the social dimension—particularly public engagement, environmental education, and community participation—is insufficiently explored. Therefore, this study investigates the potential contribution of cultural institutions, particularly museums, to stakeholder engagement and community-based wetland management. The research adopts a qualitative approach, combining conceptual analysis with case-based examples of educational and outreach practices implemented by cultural institutions. It examines how exhibitions, participatory programs, and interdisciplinary collaborations can communicate the ecological, cultural, and socio-economic significance of wetlands to diverse audiences, including local communities, students, and policymakers. The analysis shows that these initiatives contribute to increased visitor engagement, improved understanding of wetland ecosystems, and greater interest in local conservation actions. Museums act as mediators between scientific knowledge and the public by translating complex information into accessible and context-specific narratives. In addition, participatory formats create opportunities for dialogue and encourage community members to become more actively involved in environmental issues. The findings suggest that cultural institutions can complement formal conservation strategies by fostering place-based learning and strengthening connections between communities and their natural environment. Integrating such practices into wetland governance frameworks can support more inclusive and socially grounded approaches to conservation. The study highlights the practical value of museum-based engagement as a replicable model for enhancing public participation in wetland protection.

Keywords: *community engagement, cultural institutions, environmental education, museums, sustainability, wetland conservation*

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SUSTAINABLE ENERGY VALORIZATION OF MOUNTAIN WETLANDS: AN ENGINEERING-ORIENTED WATER–ENERGY NEXUS APPROACH IN NORTHERN ROMANIA

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Abstract

Wetlands constitute complex socio-ecological systems with a fundamental role in hydrological regulation, carbon sequestration, and climate resilience, while also interfacing with energy-related infrastructure and water management processes. In Maramureş County (Northern Romania), the spatial configuration of lakes, fish ponds, marshes, and oligotrophic peatlands outlines a representative mountain wetland network characterized by high ecological sensitivity and strategic relevance for integrated water–energy system planning. This paper evaluates the potential for sustainable, low-impact energy valorization of wetlands using an engineering-oriented framework, supported by hydrological modelling, GIS-based spatial analysis, and ecosystem services assessment. The study builds on monitoring datasets and project-based research generated between 2019 and 2026, focusing on the compatibility between technical feasibility and conservation constraints. The analysis considers micro-hydropower integration within existing hydraulic structures and small reservoirs, as well as the indirect contribution of peatlands to climate mitigation through long-term carbon storage and flow regulation. The methodological approach is demonstrated through site-specific case studies, including the Deseşti–Iezerul Mare peatland complex, the Moisei–Tăul lui Ciumău wetland system, and selected mountain wetlands within the Maramureş Mountains Natural Park. Results indicate that preserving natural hydrological regimes enhances system resilience, reduces environmental risk, and supports coherent water–energy planning outcomes, in line with the water–energy nexus framework promoted at European level. The findings emphasize the necessity of a multidisciplinary, conservation-aligned engineering approach, consistent with the objectives of the WeVaRe project and current European climate and ecosystem restoration policies.

Keywords: *climate resilience, GIS-based analysis, hydrological modelling, mountain wetlands, water–energy nexus.*

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CONSUMER PERCEPTION OF THE RETURN-GUARANTEE SYSTEM (RETURO-SGR) IN WETLAND AREAS: A CASE STUDY OF ROMANIA

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Abstract

The subject addressed in this questionnaire aims to gather information about how we, as consumers, perceive the return guarantee system, RETURO SGR, particularly in wetland areas (delta, lakes, ponds, marshes, floodplain meadows).

This questionnaire aims to analyze the perception of consumers in wetland areas regarding the return guarantee system (RETURO-SGR), a program recently introduced in Romania with a direct impact on recycling behaviors and the protection of fragile aquatic ecosystems. The study was conducted on a sample of 303 respondents from wetland areas (including localities in the Danube Delta, the lake region, and the Danube floodplain), with the objective of identifying the level of information, the degree of involvement, and the motivations related to packaging return in the context of preventing aquatic environment pollution. The results highlight a high level of knowledge of the system, a largely positive attitude towards recycling, and a high degree of acceptance of the guarantee value of 0.50 lei. The study also highlights the main problems encountered by consumers in wetland areas (for example, limited access to SGR machines in isolated localities or during flood periods) and potential directions for improving the program adapted to these sensitive territories. The questionnaire was applied in October 2025 and included 15 questions, addressed to 303 respondents of different ages, educational levels, and types of wetlands (delta, lakes, marshes, ponds). The main purpose of the research is to evaluate how consumers in these areas perceive and use the return guarantee system (RETURO-SGR), considering their involvement in the recycling process of PET, glass, and aluminum packaging, as well as the system's role in reducing waste that ends up in protected waters and wetlands. The study provides a relevant picture of the level of information, willingness to continue the program, frequency of return, and problems encountered when using SGR devices in wetland environments. Furthermore, the results allow for the identification of motivational factors and main barriers specific to

wetlands, thus contributing to understanding the social, economic, and ecological impact of the program on biodiversity conservation and water quality.

Keywords: *consumer, return guarantee, wetlands, aquatic environment, guarantee value, motivation, conservation, Danube Delta, floods.*

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ECO-PACKAGING, GREEN CONSUMERS, AND WETLAND REVITALIZATION: A ROMANIAN CASE STUDY ON SUSTAINABILITY AND RURAL DEVELOPMENT

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Abstract

In a society increasingly concerned about environmental impact, sustainable packaging solutions are becoming increasingly popular among both consumers and producers. These are packaging solutions that use recyclable, biodegradable or reusable materials, being a direct solution to reduce pollution and promote sustainability. However, the widespread adoption of these solutions depends mainly on their acceptance by consumers and the economic viability of their production. The aim of this case study is to investigate how consumers in Romania perceive these eco-friendly solutions and what difficulties and benefits are related to the introduction of sustainable packaging on the market. The case study highlights the main criteria that influence consumer preferences, including the type of packaging they prefer when buying a product, whether they would be willing to pay more for products with sustainable packaging, or how likely they are to support brands that actively promote sustainability initiatives in the future. Sustainable packaging is an important solution for reducing environmental impact. On the Romanian market, the implementation of sustainable packaging solutions is influenced by European legislative requirements and consumer behavior, as consumers are increasingly attentive to choosing products with a low environmental impact. Market viability depends on factors such as the cost of materials used, the ability of companies to adapt to change, and the willingness of consumers to pay more for sustainable products. Research shows that approximately 45% of Romanian consumers are willing to pay 10% more for products that use environmentally friendly packaging. Furthermore, the cost-benefit ratio is essential for manufacturers, as the adoption of sustainable packaging solutions can attract new consumer segments and increase their loyalty. In addition to the direct benefits to the environment and consumer behavior, the process of adopting sustainable packaging is of major importance for rural development in wetland areas. In these regions, where economic activities are often dependent on local natural resources (such as agriculture, fishing, or ecotourism), the implementation of a sustainable packaging system can stimulate local economies. For example, the collection and

recycling of biodegradable materials can generate new jobs in rural areas, reduce water and soil pollution in wetlands (which are particularly vulnerable), and support the creation of short supply chains for local products. Thus, the transition to sustainable packaging becomes a catalyst not only for environmental protection but also for the economic and social revitalization of rural communities in deltas, marshes, and floodplains.

Keywords: *consumers, eco-friendly, sustainability, packaging, rural development, wetlands*

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