“ALEXANDRU IOAN CUZA” UNIVERSITY OF IAȘI

FACULTY OF GEOGRAPHY AND GEOLOGY

DOCTORAL SCHOOL OF GEOSCIENCES

SUMMARY OF THE DOCTORAL THESIS

Geomorphosites and Geotourism in the Moldavian Plateau between the Siret and Prut Rivers. Tourism Potential and Valorization

Scientific supervisor:
Assoc. Prof. Dr. Habil. Eng. **Lilian NIACȘU**

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Contents

Introduction

The present doctoral thesis analyses the relief of the Moldavian Plateau from an integrated geomorphological perspective, with the aim of highlighting and valorizing its geotourism potential, which is often underestimated in comparison with mountain relief units. The research is based on the correlation of morphometric, morphographic, genetic, and dynamic characteristics of the relief with current geomorphological processes, within a framework adapted to modern concepts of geotourism and geoheritage. Through a staged approach combining field analysis, bibliographic documentation, and GIS-based methods, the study contributes to updating knowledge on the evolution of relief and to outlining a distinct geographical identity of the Moldavian Plateau. The obtained results provide a solid scientific basis for the mapping and valorization of geotourism resources, at both regional and urban levels, with direct applications in spatial planning and sustainable tourism development.

Context and importance of geomorphosites and geotourism

The practical implementation of the need, expressed both by specialists in the field of geography and by society in general, for studies based on contemporary concepts developed in the specialized literature is both beneficial and useful in various contexts.

In Romania, scientific works dedicated to this topic – geotourism - are relatively few in number, and a comprehensive study addressing geotourism as a whole is still lacking. At present, an increasing number of researchers are involved in projects related to geoconservation, geoparks, and geotourism, positively influencing public perception of Earth sciences. Among these initiatives, geoparks have proven to be excellent tools for public education in Earth sciences, while also representing important areas for recreation and for significant sustainable economic development through geotourism.

In this context, the Moldavian Plateau exhibits a wide variety of geomorphosites which, in most cases, are insufficiently valorized or, in some instances, not valorized at all. Geotourism has the potential to modify and shape people’s perceptions in various ways, ranging from what sociologists describe as “collective visual consumption” to the establishment of relationships with alternative forms of tourism, capable of opening up multiple horizons.

In order to achieve these objectives, the importance of relief must be understood not only as a space of impact, but also in terms of its landscape, environmental, and social roles (historical and archaeological sites, religious landmarks, biodiversity, etc.). The development of this phenomenon can occur simultaneously with the advancement of geoconservation and geoparks, as well as with the use of geomorphosites and geosites, in general, within tourism activities, while taking into account the principles of sustainable tourism.

Most contemporary tourists no longer wish to be mere spectators or passive recipients of tourism services; instead, they seek to understand certain aspects related to the targeted tourism objectives, such as their origin, evolution, and relationship with human society. Tourist motivation often varies from one type of tourist to another, ranging from travel as exploration or initiation into new places to travel with a scientific (educational) purpose, aimed at understanding specific phenomena, tourism being frequently perceived as a way of life. Geomorphology, through the description of relief, should therefore be understood as an evaluation of the geometric characteristics of the Earth’s surface in all its diversity, an evaluation that leads to a genuine understanding of the geotourism potential of relief and provides opportunities for a wide range of tourism-related activities.

Thus, in recent decades, with regard to the application of geomorphological components in tourism activities, increasing emphasis has been placed on the development of concepts such as geomorphosite, geosite, geotope, geodiversity, geotourism, and cultural geomorphology.

Aim and objectives of the research

The main aim of this research is to analyse, evaluate, and valorize the geomorphosite potential of the Moldavian Plateau located between the Siret and Prut rivers, emphasizing their importance for the development of geotourism and the promotion of sustainable tourism based on geomorphological heritage. The present study focuses on the identification, classification, and analysis of geomorphosites within the region, as well as on the identification of strategies for their tourism valorization, with the ultimate objective of integrating them into coherent tourism circuits.

Therefore, the main objectives of the present research can be grouped as follows:

1. Inventory and classification of geomorphosites

- Identification of geomorphosites in the Moldavian Plateau based on fundamental scientific criteria (geomorphological, geological, etc.), as well as complementary criteria (ecological, economic, aesthetic, etc.).
- Development of a typological classification of geomorphosites in the region, taking into account genetic factors, geomorphological dynamics, and their geolandscape value.
- Mapping and spatial analysis of geomorphosites using Geographic Information Systems (GIS).

2. Evaluation of the geotourism potential of geomorphosites

- Application of modern methodologies for geomorphosite assessment, using objective criteria such as scientific, educational, aesthetic, and cultural value.
- Correlation of geomorphosite characteristics with the requirements of sustainable tourism and contemporary tourism experiences.
- Analysis of anthropogenic impact on geomorphosites and identification of risks associated with their degradation.

3. Development of a case study on geotourism development within an emblematic geomorphosite in the Iași area - Dealul Repedea

- Analysis of the specific geotourism characteristics of the Repedea site.
- Evaluation of existing infrastructure and the degree of tourism accessibility of the site.
- Proposal of geotourism development and conservation strategies for the sustainable valorization of the site.

4. Integration of the geological and geomorphological heritage of the investigated area into the cultural tourism of the city of Iași

- Analysis of the use of geological materials in the built historical heritage of Iași and their importance as elements of cultural heritage.
- Proposal of thematic tourism routes including elements of geological heritage, contributing to the development of educational tourism and geotourism.

5. Formulation of recommendations for geotourism development in the Moldavian Plateau

- Identification of the main opportunities and constraints related to geotourism development in the region.
- Development of strategies and policies for promoting geotourism, including collaboration with local authorities, environmental organizations, and tourism agencies.
- Establishment of future research and development directions for improved integration of geomorphosites into national and international tourism networks.

These objectives are addressed through a complex methodology, which includes field research methods, geostatistical analyses, multicriteria assessments, and comparative studies, thereby contributing to the development of an integrated perspective on geotourism in the Moldavian Plateau.

Chapter 1: Theoretical and methodological foundations regarding geosites and geotourism

1.1. Geodiversity and geolandscape

The first part of the chapter clarifies the manner in which the concept of geodiversity is used within the present research, starting from the established definitions in the specialized literature (Gray, 2004; Brilha et al., 2018). Geodiversity is approached as the ensemble of abiotic components of the environment, including geological, geomorphological, pedological, and hydrological elements, as well as the processes associated with them. The relationship between geodiversity and biodiversity is discussed, with the abiotic environment being regarded as the support of ecosystems, as well as the role of geodiversity in the dynamics of the natural environment and in the transformation of landscapes over time. In this context, a conceptual scheme is employed that synthesizes the main components of geodiversity and the relationships among them (Figure 1).

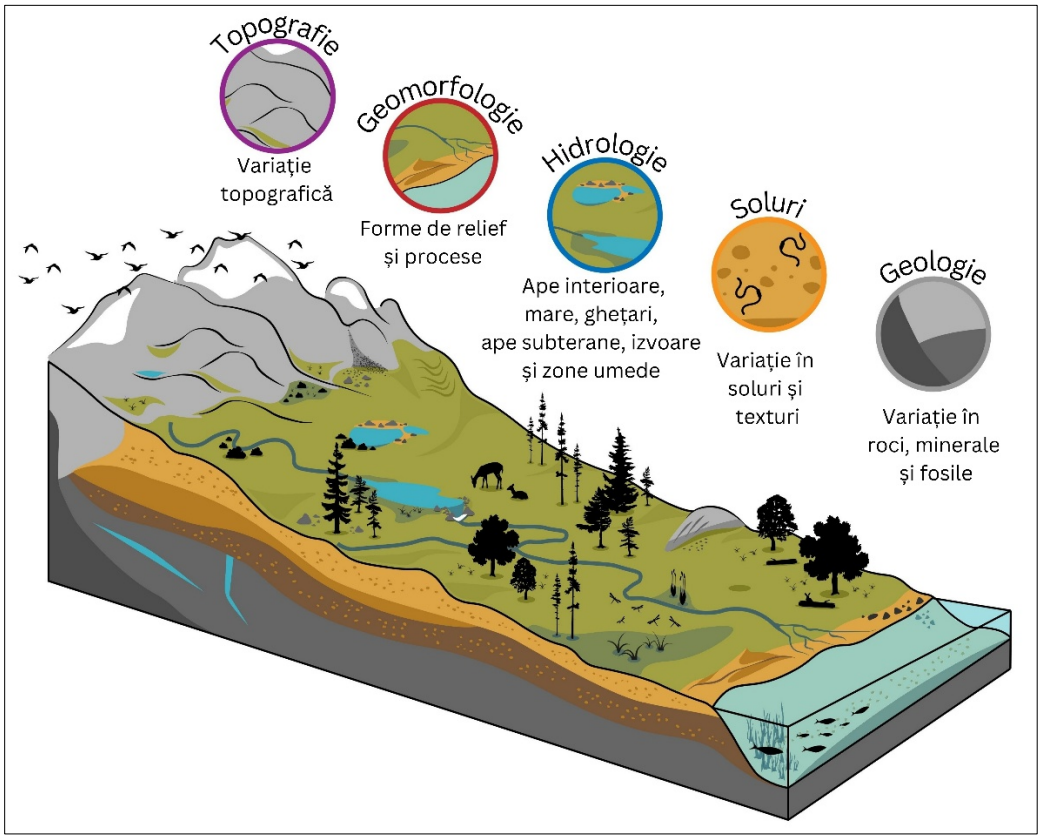


Figure 1. Geodiversity and its components, developed by Tukiainen et al. (2022) based on the definition proposed by Gray (2013)

Subsequently, the concept of geolandscape or geomorphological landscape is analysed, defined as the result of the interaction between geodiversity, climatic, hydrological, and biotic factors, and anthropogenic activities (Panizza & Piacente, 2003). The geomorphological landscape is approached as a dynamic system, undergoing continuous evolution, which can be analysed from both a scientific and an educational and tourism-related perspective. The main methodological approaches used in geolandscape studies are presented, with emphasis on mapping, the use of Geographic Information Systems (GIS), and spatial analysis (Zwoliński, 2009), highlighting their role in understanding relief evolution and in integrating geodiversity and geolandscape into strategies of geoconservation, spatial planning, and geotourism development.

1.1.1. Evolution of the concept of geodiversity: a historical perspective

The evolution of the concept of *geodiversity* is analysed through a staged approach that reflects the main shifts in perspective within geographical and geological sciences. This approach allows the identification of the transition from a predominantly descriptive view of the abiotic components of the environment to an integrative one, in which geodiversity is correlated with nature conservation, ecosystem functioning, and sustainable development.

The first stage, corresponding to the late nineteenth century and the early twentieth century, is characterized by a descriptive approach to geology and geomorphology. During this period, abiotic elements were analysed mainly from the perspective of structure and resources, being considered a relatively inert support for biological and climatic phenomena (Gray, 2004; Reynard & Coratza, 2013). The concept of geodiversity was not explicitly formulated, and concerns regarding the conservation of abiotic heritage were limited, with research focusing on mapping, the description of geological formations, and the classification of relief forms (Brilha, 2018). In Romania, the development of geological and geomorphological studies during this period occurred under the influence of European scientific schools, contributing to the foundation of knowledge regarding relief and geological substrate, but without their explicit integration into a conservation-oriented conceptual framework.

The second stage, corresponding to the late twentieth century and the early twenty-first century, marks the emergence and consolidation of the concept of geodiversity in the specialized literature. The term was introduced in the context of geological and geomorphological conservation, and the proposed definitions highlight the diversity of geological, geomorphological, pedological elements and their associated processes (Sharples, 1993; Kiernan, 1996; Gray, 2004).

During this period, geodiversity became recognized as a distinct component of natural heritage and was conceptually differentiated from notions such as geoconservation and geoheritage. At the same time, the first qualitative and quantitative methods for geodiversity assessment were developed and applied in mapping, territorial management, and the identification of areas with scientific value and geotourism potential (Serrano & Ruiz-Flaño, 2007; Brilha, 2018). In Romanian literature, these directions were adopted and adapted in studies addressing the relationship between geodiversity, geomorphosites, and the tourism valorization of natural heritage (Andrășanu, 2008; Comănescu & Nedelea, 2010).

A more recent stage is represented by the functional approach to geodiversity, in which it is analysed in relation to the provision of ecosystem services, the management of geomorphological hazards, and conservation policies. Contemporary studies emphasize the role of geodiversity in regulating hydrological processes, slope stability, and soil quality, as well as its integration into spatial planning and sustainable development strategies (Gray, 2013; Schrodt et al., 2024). In this context, geoparks and protected areas become relevant instruments for the conservation and educational and tourism valorization of geological and geomorphological

heritage, including in Romania, where they are gradually integrated into regional development strategies (Ilie & Grecu, 2023).

Through this staged analysis, the subchapter highlights how the evolution of the concept of geodiversity has provided the theoretical foundation for the approach to geomorphosites and geotourism, topics further developed in the applied chapters of the thesis.

1.1.2. Geolandscape - an integrated expression of natural and anthropogenic factors

1.1.2.1. Evolution of the landscape concept in Geography

The evolution of the concept of landscape is analysed starting from its transformation from a notion with predominantly artistic and philosophical connotations into a scientific concept used in the analysis of the geographical environment. The first systematic approaches emerged in the nineteenth century, with the works of Humboldt, which introduced an analytical perspective on landscape based on the relationships among natural elements and their spatial distribution.

Subsequently, the development of geography led to an integrated interpretation of landscape, in which emphasis was placed on the interaction between natural and anthropogenic components. An important role in this evolution was played by geosystem theory, which highlighted the dynamic character of landscape and the exchanges of matter and energy among its constituent elements (Bertrand, 1968; Soceava, 1975). On this basis, landscape was integrated into a hierarchical system of analysis, applicable at different spatial scales, from the global to the local level, emphasizing the importance of a multi-scalar approach in geographical research (Drăguț, 2000).

The definitions formulated in the specialized literature converge toward the idea that landscape represents a distinct territorial unit resulting from the complex interaction between natural and anthropogenic elements, continuously transformed under the influence of geodynamic processes and human activities (Panizza, 1988, cited in Ilieș & Josan, 2009). This perspective is reinforced by contemporary approaches, such as that promoted by the European Landscape Convention, which treats landscape as a dynamic system with ecological, cultural, and functional value, relevant to sustainable development (Council of Europe, 2000).

Within geography, landscape analysis involves the integration of multiple dimensions - spatial, temporal, functional, and perceptual - which enable an understanding of how landscapes evolve and are perceived by society. This multidimensional approach provides the conceptual basis for defining the geomorphological landscape or geolandscape (Ilieș & Josan, 2009), understood as an expression of the interaction between geodiversity, natural processes, and anthropogenic activities (Panizza & Piacente, 2003). From this perspective, relief and geological structure represent the fundamental framework of the landscape, and the analysis of geolandscapes goes beyond the simple description of relief forms, encompassing the ways in which they are perceived, used, and managed over time (Stuber, 1997; Dincă, 2005).

1.1.2.2. Classification of geolandscapes

The classification of geolandscapes in this thesis is based on geomorphological criteria and the degree of anthropogenic intervention. In the specialized literature, geolandscapes are differentiated according to dominant processes, with types such as karst, fluvial, glacial, or periglacial geolandscapes being identified (Reynard et al., 2003).

In order to reflect landscape complexity, this typology is complemented by a functional classification, which distinguishes primary, secondary, and hybrid geolandscapes, depending on their origin and the intensity of anthropogenic transformations. This approach allows the integration of geolandscapes into analyses concerning geomorphosites and their geotourism valorization.

1.1.2.3. Methodology for geolandscape analysis

The methodology for geolandscape analysis is approached from an integrated perspective, combining spatial, functional, typological, and predictive analysis, while adapting classical methodological directions of landscape studies to geomorphological specificities (Roșu & Ungureanu, 1977). This approach enables the assessment of the territorial organization of geolandscapes, the dynamics of geomorphological processes, and their evolution under the influence of natural and anthropogenic factors.

The integration of modern geospatial analysis methods and digital cartography provides the methodology with practical applicability in geomorphological heritage conservation, spatial planning, and natural hazard management.

1.2. Geosites - concept, characteristics, and their relationship with geomorphosites

Geosites are defined as well-delimited elements of the geosphere with scientific, educational, aesthetic, or cultural value, which enable the understanding of Earth's evolution and geodynamic processes (Andrășanu, 2006; Panizza & Piacente, 2003). Within this category, geomorphosites represent a specific subset, highlighting the role of relief forms and geomorphological processes, with direct relevance to geoheritage and the development of geotourism.

1.3. Geomorphosites

Geomorphosites are relief forms with scientific, educational, aesthetic, and cultural value, which reflect the geological and geomorphological evolution of a territory. They result from the interaction of natural processes and may constitute both elements of geomorphological heritage and resources for educational and tourism related activities..

1.3.1. Definition of the concept of geomorphosite

The concept of geomorphosite refers to a well-delimited territorial unit characterized by the presence of relief forms or geomorphological processes that are significant for understanding the geological and geomorphological evolution of a territory, as well as the relationships between abiotic and biotic factors (Grandgirard, 1997; Panizza, 2001; Reynard, 2004a; Reynard, 2004b). In the specialized literature, geomorphosites are considered distinct components of geoheritage, often treated as a subtype of geosites, with a specific emphasis on the geomorphological value of relief (Panizza & Piacente, 2003). Unlike relief forms analysed exclusively from a physical-geographical perspective, geomorphosites are defined through a process of valorization, in which their significance derives not only from their natural characteristics, but also from the way they are perceived, interpreted, and used by society. In this sense, geomorphosites do not fully overlap with natural tourist attractions, although some of them may also acquire tourism functions due to their aesthetic, cultural, or educational value.

A central element in the definition of geomorphosites is the process of "optimization", through which relief forms and geomorphological processes acquire heritage value and valorization potential, depending on the socio-cultural context and human perception (Panizza, 2001; Pralong & Reynard, 2005). This process is schematically summarized in Figure 2, which highlights the stages of optimization, exploitation, and transformation of geomorphology in the context of tourism development.

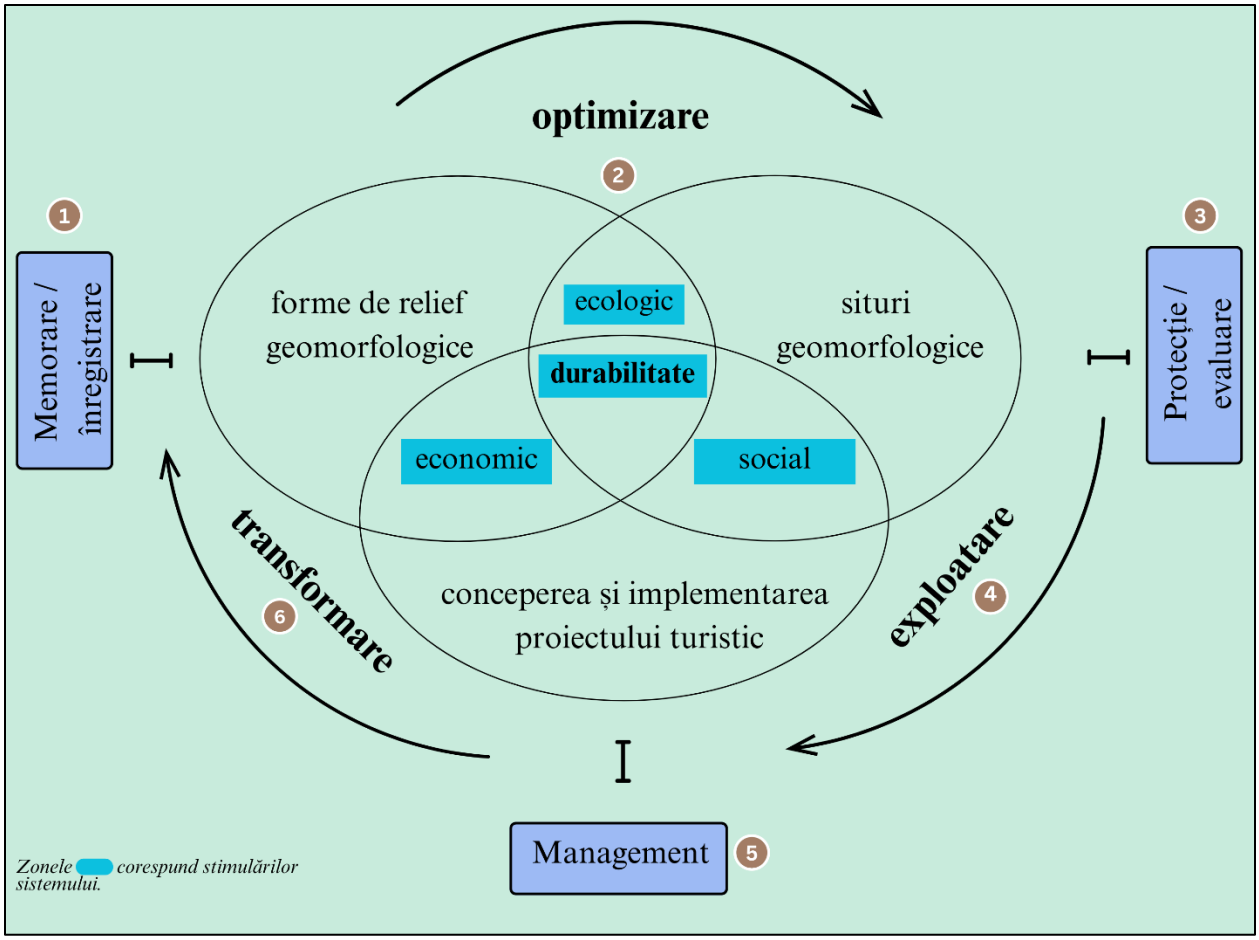


Figure 2. Conceptual model describing the optimization, exploitation, and transformation of geomorphology in the context of tourism development, proposed by Pralong & Reynard (2005).

Following optimization, geomorphosites may be oriented either toward protection, in the case of vulnerable sites, or toward controlled exploitation, becoming a support for tourism and educational facilities. Such interventions may generate modifications of the initial geomorphology, leading to the emergence of "second-generation" geomorphological forms and processes, integrated into the evolution of the tourism landscape (Pralong & Reynard, 2005).

The specialized literature highlights the existence of two main levels of values associated with geomorphosites: scientific value, considered defining for the inclusion of a geomorphological element in this category, and additional values, of an aesthetic, cultural, ecological, or economic nature, which facilitate their integration into conservation, education, and tourism policies (Reynard, 2004; Reynard et al., 2007).

The terminological and conceptual diversity associated with geomorphosites reflects the evolution of scientific approaches and the progressive integration of cultural and functional dimensions into the analysis of relief. In this context, the present research provides a comparative synthesis of the main terms used in geomorphological literature, presented in Table 1, which

includes, alongside classical evaluation criteria, the criterion of geomorphological resilience, proposed as a complementary analytical tool.

Table 1. Conceptual synthesis of terms used for geomorphosites and the integration of the geomorphological resilience criterion (after Reynard, 2005; Comănescu et al., 2009, with additions).

Term	Equivalent term in international literature	Bibliographic references	Evaluation criteria and types of values	Classification according to geomorphological resilience
Geomorphological values / assets	Geomorphological assets / *Biens géomorphologiques*	Panizza & Piacente, 1993; Quaranta, 1993	Aesthetic evaluation (intuitive) and scientific evaluation (quantitative)	High stability, very weakly affected by exogenous factors; maintain their initial characteristics over long periods of time
Geomorphological goods	Geomorphological goods / *Biens géomorphologiques*	Carton et al., 1994	Multi-attribute evaluation: scientific, aesthetic and cultural; value determined by palaeogeomorphology, rarity and educational role	Slow temporal modification, moderate impact of climatic and anthropogenic factors; visible evolution only in the long term
Geomorphosites	Geomorphological sites / *Sites géomorphologiques*	Hooke, 1994	Three main values: aesthetic, ecological and educational, including the observation of geomorphological processes	Active evolution, influenced by climatic and anthropogenic factors; require monitoring and protection
Geomorphological geotopes	Geomorphological geotopes / *Géotopes géomorphologiques*	Grandgirard, 1995, 1997, 1999	Geomorphological element whose value is formally recognised; important for geodiversity and natural heritage	High vulnerability, sensitive to erosion and geodynamic processes; require protection measures
Sites of geomorphological interest	Sites of geomorphological interest / *Sites d'intérêt géomorphologique*	Rivas et al., 1997	Evaluation based on scientific, educational and touristic interest	High exposure to degradation, major impact of tourism and anthropogenic activities; require active conservation strategies
Geomorphosites	Geomorphosites / *Géomorphosites*	Panizza, 2001	Landforms to which scientific and cultural values can be attributed	Susceptible to accelerated degradation; high risk of destruction due to anthropogenic activities and climate change; require strict protection

Through this approach, geomorphosites are defined as interface elements between geomorphology, heritage conservation, and tourism valorization, providing a coherent theoretical framework for the applied analyses developed in the subsequent chapters of the thesis.

1.3.2. General aspects regarding the classification of geomorphosites

Geomorphosites can be classified according to the nature of relief forms, geomorphological processes, and the assigned value, depending on the purpose of the analysis.

1.3.2.1 Temporal criterion

According to the temporal criterion, geomorphosites are classified as active, characterized by ongoing geomorphological processes with scientific, educational, and climate-change monitoring value (Reynard, 2004a; Bollati et al., 2011), and passive, which represent relics of past processes and function as palaeogeomorphological archives of landscape evolution (Reynard, 2005; Pelfini & Bollati, 2014).

This distinction is fundamental for vulnerability assessment, risk management, and conservation strategies of geomorphological heritage (Panizza & Piacente, 2003; Gordon, 2019).

1.3.2.2. Genetic criterion

According to the genetic criterion, geomorphosites are classified based on dominant geomorphogenetic processes and on the relationship between geological substrate and relief dynamics, this approach allowing for palaeogeographical reconstructions and for substantiating the scientific value of the sites (Necheș, 2013; Bollati et al., 2017).

Although the literature proposes a variety of typologies (karstic, structural, fluvial, glacial, etc.), the lack of a unitary taxonomy leads to terminological heterogeneity, with implications for the comparability and evaluation of geomorphosites in conservation and geotourism contexts (Cocean & Cocean, 2017; Bussard & Giaccone, 2021; Ruiz-Pedrosa et al., 2024).

1.3.2.3. Tourism importance criterion

According to the criterion of tourism importance, geomorphosites can be classified into sites of local/regional, national, and international interest, depending on their tourism attractiveness and level of public recognition (Barbălată & Comănescu, 2021; Ruiz-Pedrosa et al., 2024). This hierarchization reflects the level of tourism valorization and the degree of integration of geomorphosites into promotion and protection strategies, including international initiatives such as UNESCO Global Geoparks (Ruiz-Pedrosa et al., 2025).

1.3.2.4. Dimensional criterion

According to the dimensional criterion, geomorphosites are classified as point, linear, areal, and complex, depending on their spatial extent and the organizational pattern of relief forms (Zouros, 2005; Cocean, 2011; Santos et al., 2020).

This classification has direct implications for conservation and tourism valorization, facilitating the adaptation of management measures to the scale and complexity of each site (Panizza & Piacente, 2003).

1.3.3. Types of geomorphosites specific to the Moldavian Plateau

1.3.3.1. Geology and geomorphosites

Building on the theoretical aspects presented above, and based on the genetic criterion, this research proposes the introduction of a new terminological concept – geologosite - derived from the combination of the terms geological and geomorphosite. The term is conceived to designate those geomorphosites in which the expression of relief is decisively influenced by the structure and composition of the geological substrate, and in which morphogenetic processes are clearly controlled by these endogenous characteristics. Unlike sites dominated by exogenous processes (such as fluvial or aeolian erosion), geologosites express a direct functional correlation between geology and geomorphology, reflected in the spatial configuration of relief forms and in their heritage value.

A geologosite can be defined as a geomorphological unit (relief form) in which genesis, morphology, and geolandscape significance are directly influenced by the geological characteristics of the substrate, particularly internal structure, lithological composition, and the spatial arrangement of formations. The value of such a site derives from the interaction between geology and relief morphology, conferring scientific, aesthetic, and educational relevance, as well as a high potential for geotourism and heritage valorization.

Frequently, the concept of geomorphosite is associated with the field of geology and integrated into broader themes such as geodiversity, geoconservation, or geological heritage. However, this predominantly geological association does not fully reflect the complexity of the concept, which in fact implies a clear interconnection between geology and geomorphology. Relief results from the interaction between substrate structure and exogenous processes, and the value of

a geomorphosite derives precisely from this dual perspective. Consequently, both geological and geographical (geomorphological) approaches should be regarded as complementary, without privileging one at the expense of the other.

In this sense, the geologosite, as a subcategory of the geomorphosite, emphasizes the role of the geological substrate in defining relief forms, while fitting naturally within the broader framework of applied geomorphology and geomorphological landscape assessment.

Beyond relief forms directly influenced by the structure and composition of the geological substrate, the category of geologosites also includes other components with clear geomorphological and geological value, such as geological reserves, palaeontological reserves (fossiliferous points or sites), reference stratigraphic outcrops, tectonic structures visible in the field, or geological formations with distinct lithostratigraphic and palaeogeographical characteristics.

Within the category of geologosites, applicable to the specific natural framework of the geographical unit of the Moldavian Plateau, taken as a case study in the present research, several types of units with clear geomorphological and geological value can be distinguished, whose relevance derives from the interaction between the geological structure of the substrate and the morphological expression of relief in this region. Among these, the most significant are: (1) geological reserves; (2) palaeontological reserves (fossiliferous points or sites); and (3) reference stratigraphic outcrops.

In this context, the detailed analysis of geological and palaeontological reserves, as well as of stratigraphic outcrops in the Moldavian Plateau, allows for highlighting the role of the geological substrate in shaping geomorphosites and in defining their scientific, educational, and geotourism potential.

1.3.3.2. Geomorphology and geomorphosites

După As presented above, the specialized literature has outlined several criteria for the classification of geomorphosites, applied depending on research objectives and the territorial specificity under analysis. Some approaches prioritize the temporal dimension, distinguishing between active geomorphosites - often associated with ongoing processes, such as volcanoes (Páez & Ramírez, 2020) or gullies (Zgłobicki et al., 2019) - and passive geomorphosites, considered “archives” of palaeoenvironments and of previous stages in the evolution of relief (Reynard, 2004a; Pelfini & Bollati, 2014). Other classifications are functional or value-based, focusing on the educational, scientific, aesthetic, or cultural role of sites (Brilha, 2016; Comănescu & Nedelea, 2010). In addition, integrative typologies exist, combining morphographic criteria with elements of natural and cultural heritage (Bollati et al., 2017).

Among these possibilities, the genetic criterion is the most appropriate when the aim is to capture the causal connection between the geological substrate, morphodynamic processes, and the expression of the present-day landscape. This option has the advantage of providing a coherent explanatory framework, being applicable comparatively across regions, and supporting the identification of vulnerabilities and geotourism potential of sites (Necheș, 2013; Ruiz-Pedrosa et al., 2024).

Based on the genetic criterion and taking into account the geomorphological specificity of the Moldavian Plateau, which constitutes the case study of the present research, a general taxonomic scheme of geomorphosites is proposed, organized into four main categories, namely: (I) geologosites, (II) structural-lithological geomorphosites, (III) fluvio-denudational geomorphosites, and (IV) anthropic geomorphosites. This typology aims not only at a descriptive grouping of relief forms, but also at highlighting the connection between the geological substrate,

geomorphological processes, and the landscape expression of the study area, which will be discussed in detail in the following chapter.

The first category within this typology - geo(logo)sites - was analysed separately in subchapter 1.3.3.1, given their importance for understanding the direct relationship between the geological substrate and morphological expression. The present section addresses the remaining three major categories of geomorphosites, namely structural - lithological, fluvio-denudational, and anthropic geomorphosites, which complete the proposed genetic classification scheme.

Structural - lithological geomorphosites include geomorphosites whose formation is closely linked to structural - lithological relief forms. In these cases, the arrangement and differential resistance of rocks determine the development of characteristic forms, while exogenous processes primarily act to reveal and accentuate these features. Their importance lies in the fact that they clearly convey the relationship between geology and geomorphology (relief), providing valuable information for understanding territorial evolution.

At a general level, the main subtypes identified within the study area are:

1) **Structural - lithological plateaus,** preserving levelled surfaces developed on resistant strata arranged within the typical monoclinic structure of the investigated area;
2) **Structural - lithological ridges,** following ridge lines superimposed on structural elements;
3) **Structural - lithological scarps and gorge valleys,** resulting from river incision into compact formations or along lithological and even tectonic discontinuities;
4) **Cuesta scarps (slopes),** characterized by slope asymmetry conditioned by the generally monoclinic structure;
5) **Grottos, caves, and karstic and calcareous scarps,** specific to karst and limestone relief;
6) **Mud volcanoes,** forms specific to relief developed on clays, where soil plasticity generates features such as mud volcanoes or marshy terrains.

These geomorphosites possess scientific value through their ability to highlight the relationship between rock and form, as well as educational and tourism value, since they provide clear and visible examples of interaction between geology and modelling processes. At the same time, they are sensitive to human intervention (resource exploitation, deforestation) and to natural processes (landslides, collapses), which necessitates their protection and responsible valorization.

Fluvio-denudational relief includes geomorphosites formed through the integrated action of running water and slope modelling processes. They reflect the continuous dynamics of erosion and sediment transport and, through the resulting forms, provide information on climatic, geological, and land-use conditions..

The most frequent subtypes encountered in the Moldavian Plateau are:

1) **Badlands-type terrains,** resulting from intensive surface erosion on friable deposits, where dense networks of rills and micro-gullies develop;
2) **Gullies,** forms of deep erosion that create steep and unstable incisions, with rapid evolution and direct impact on agricultural land and infrastructure; and
3) **Landslides,** gravitational processes with evident negative effects on the environment and society, but also with scientific, educational, and didactic value.

Anthropic geomorphosites are those created or directly modified by human activity. Although they do not have a natural origin, these forms acquire geomorphological significance and can be integrated into the analysis of geodiversity and geoheritage, especially through their cultural, historical, and educational roles.

In the investigated area, this category includes:

1) **Sunken lanes,** known as sunken lanes or holloways in international literature (Zgłobicki et al., 2019);
2) **Tumuli and archaeological mounds,** which have both historical and symbolic value, as well as the function of morphological landmarks within the landscape;
3) **Earthworks and trenches,** mainly resulting from military contexts, marking linear microforms with documentary value.

These forms may have particular value in that they reflect the interaction between humans and the natural environment. From a tourism perspective, they can be included in thematic routes that highlight both natural resources and cultural heritage. At the same time, they are vulnerable to degradation, which requires their inclusion in conservation and responsible valorization programmes.

Complementing this general scheme, Romanian geographical literature shows a tendency to assign specialized suffixes (-sites) to denote membership in a thematic category - for example vulcanosites, aeolosites, glaciosites, etc. This terminological convention facilitates the identification of the dominant process that generated the respective forms and contributes to the consolidation of a common vocabulary in geomorphosite studies. However, at the international level, a greater diversity of terms can be observed, indicating that a fully unitary taxonomy has not yet been established, but rather a flexible system adapted to research context and local heritage.

In conclusion, the described genetic classification provides an important framework for understanding diversity and for substantiating conservation and valorization strategies for geomorphosites within the Moldavian Plateau. The following analysis will focus on identification and evaluation techniques, which enable the transition from the conceptual level to the applied level required for the management and promotion of the geoheritage of this area.

1.3.4. Techniques for the identification and evaluation of geomorphosites

The identification and evaluation of geomorphosites are based on the application of standardized methodologies that allow the inventory and assessment of the scientific, educational, aesthetic, and socio-economic values of relief forms, with the aim of reducing subjectivity and ensuring comparability between sites (Pereira & Pereira, 2010).

1.3.4.1. Identification and mapping of geomorphosites

The identification of geomorphosites is based on cartographic and GIS analysis, complemented by field observations, with results synthesized in standardized assessment forms and geospatial databases, which allow the production of thematic and geotourism maps (Reynard & Panizza, 2005; Comănescu, Nedelea & Dobre, 2012).

1.3.4.2. Evaluation of geomorphosites

The evaluation of geomorphosites has evolved from qualitative, expertise-based approaches to multicriteria quantitative methods, which enable a comparative assessment of scientific, educational, aesthetic, and tourism values, thereby reducing evaluation subjectivity (Reynard et al., 2007; Pralong, 2005; Serrano & González, 2005; Brilha, 2016; Pereira & Pereira, 2010).

1.3.4.3. Usefulness of geomorphosite evaluation

The results of geomorphosite evaluation constitute an important tool for the hierarchization of sites, the substantiation of geoconservation measures, and their integration into territorial management, education, and sustainable geotourism strategies (Zouros, 2005; Pereira & Pereira, 2010).

1.4. Geomorphosites and geotourism

Geotourism is a form of tourism that emerged at the end of the twentieth century, initially defined as an activity oriented toward the valorization of geological and geomorphological heritage through on-site interpretation and education (Hose, 1995; 2007), and later conceptualized as tourism focused on geodiversity, geolandscapes, and their conservation (Newsome & Dowling, 2010; Dowling & Newsome, 2018).

In its current scientific understanding, geotourism promotes the visitation of geosites and geomorphosites, fostering an understanding of geological and geomorphological processes while simultaneously protecting abiotic natural resources (Hose, 2000; Brilha, 2016). This form of tourism borrows principles from ecotourism, emphasizing sustainability, education, and the involvement of local communities (Newsome, Dowling & Leung, 2012; Henriques & Brilha, 2017).

Geomorphosites represent the core of geotourism resources, as most geotourism attractions consist of relief forms or geomorphological assemblages with high scientific, aesthetic, and educational value, transformed into tourism resources through appropriate development and interpretation (Panizza & Piacente, 2003; Reynard et al., 2009). The evaluation of geomorphosites explicitly includes criteria related to educational value and tourism potential, facilitating the selection of sites for geotourism routes and infrastructure (Pralong, 2005; Reynard et al., 2007; Comănescu et al., 2012).

An optimal institutional framework for integrating geomorphosites into geotourism is provided by geoparks, which simultaneously pursue geoheritage conservation, public education, and local socio-economic development (Zouros, 2005; Gordon, 2019). The experience of geoparks demonstrates that responsibly applied geotourism contributes to the protection of geomorphological heritage and to the sustainable valorization of natural landscapes (Ólafsdóttir & Tverijonaite, 2018).

Chapter 2: Geomorphosites and geotourism. Applications at the level of the Moldavian Plateau

2.1. Geographical setting and boundaries

Chapter 2 applies the genetic classification of geomorphosites proposed in the theoretical chapter, specifically designed for the geomorphological characteristics of the Moldavian Plateau, as an analytical tool for assessing geomorphological heritage and regional geotourism potential. The classification, structured into four main categories (geo(log)o-sites, structural - lithological geomorphosites, fluvio-denudational geomorphosites, and anthropic geomorphosites), enables the identification of the relationships between the geological substrate, active morphodynamic processes, and the current expression of relief.

Moldavian Plateau, the most extensive hilly unit in Romania, is located in the north-eastern part of the country, between the Eastern Carpathians and the Prut River valley, and is characterized by a generally monoclinal structure and pronounced geomorphological dynamics. The intensity of erosion, landslide, and relief fragmentation processes accounts for the high density of geomorphosites and supports the relevance of applying this typology for scientific and geotourism purposes. At the same time, the socio-economic disadvantaged context of the North-East Development Region gives geotourism a potential role within regional development strategies (Niacșu et al., 2021; Eurostat, 2022; Viziteu et al., 2024). The location of the study area, situated between the Siret and Prut rivers, is illustrated in Figure 3.

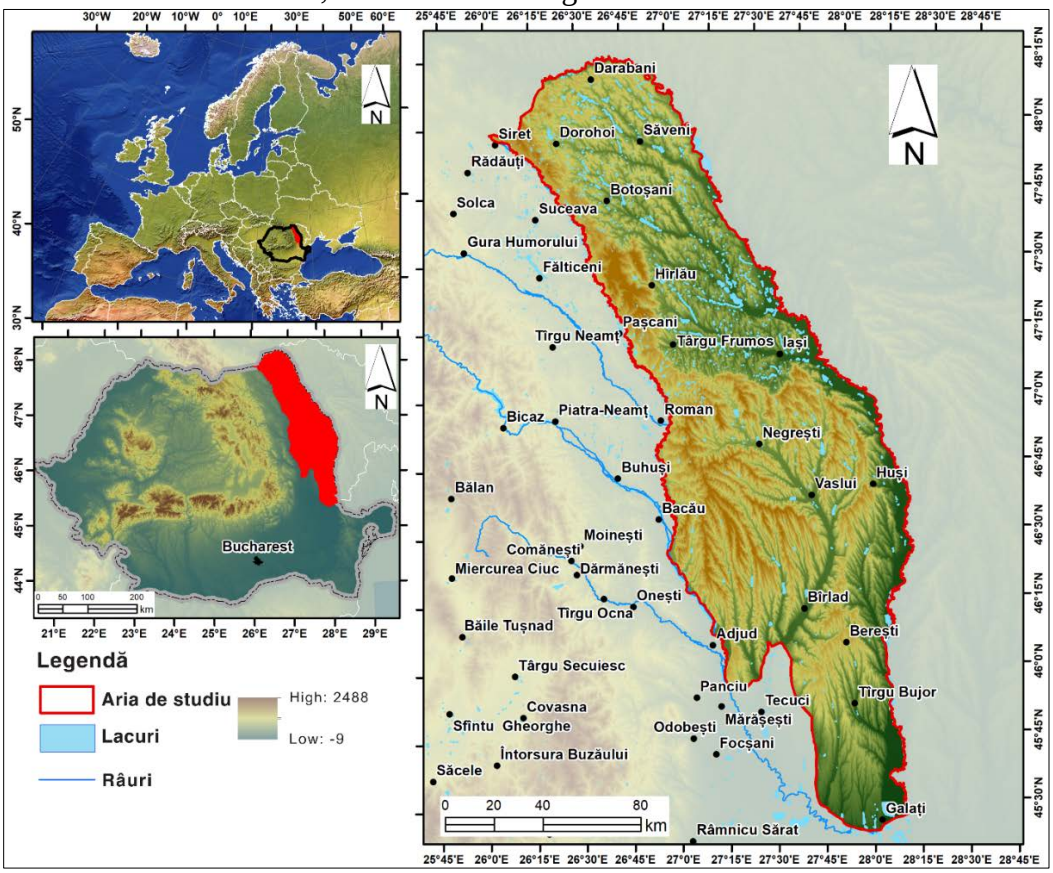
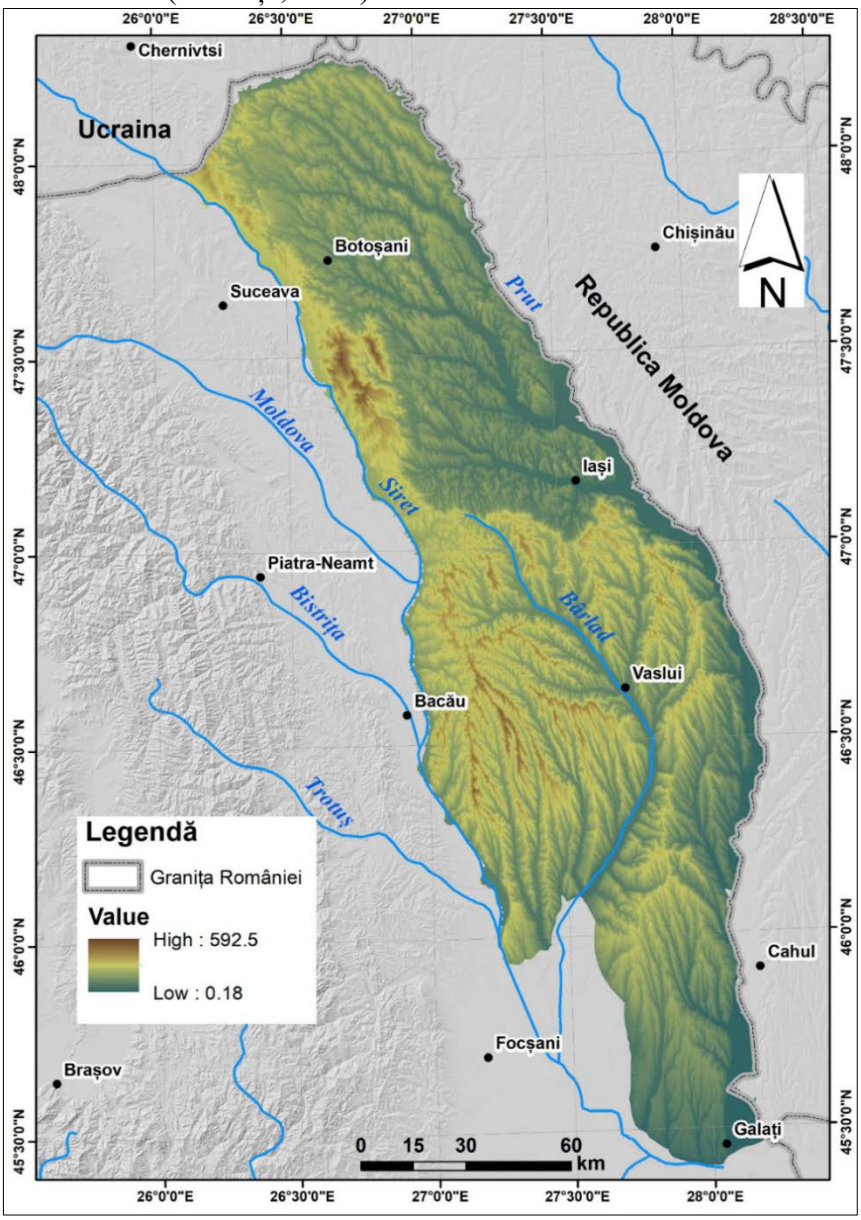


Figure 3. Location of the Moldavian Plateau (sector between the Siret and Prut rivers) in Europe and Romania

The relief of the sector between the Siret and Prut rivers is synthesized by the hypsometric model (Figure 4), which highlights the progressive decrease in altitude from west to east, from higher and more fragmented interfluves toward the Prut valley. This distribution reflects the monoclinal structure characteristic of the Moldavian Plateau, which plays a determining role in the organization of the geomorphological landscape. The sector between the Siret and Prut rivers displays a clear geomorphological differentiation, with higher and strongly fragmented areas in the west and north-west, characterized by narrow interfluves and steep slopes, and lower hilly surfaces toward the east and south-east, where lateral erosion and smoother relief dominate (Băcăuanu et al., 1980; Ungureanu, 1993). This hypsometric structure, together with the predominantly north - south orientation of valleys, explains the geomorphological compartmentalization of the Moldavian Plateau and forms the basis for the delimitation of regional subdivisions (Niculiță, 2020).



The study focuses on the eastern sector of the Moldavian Plateau, located between the Siret and Prut rivers, which covers approximately 19,820 km² (about 73% of the plateau's surface area) and is distinguished by the intensity of active geomorphodynamic processes, particularly surface and deep erosion through gullying, with one of the highest densities at the European level (Moțoc, 1983; Ichim, 1990; Rădoane, 1995, 2017; Ioniță, 2000c, 2006; Niacșu, 2012; Codru et al., 2023), as well as by the high frequency of land-slides (Mărgărint & Niculiță, 2017). The sele-ction of this area is motivated both by its high geomorphological vulnera-bility and by the fact that its geotourism potential re-mains insufficiently valori-zed in the specialized literature, compared to mountainous or karst regi-ons.

Figure 4. Digital Elevation Model (DEM) of the Moldavian Plateau between the Siret and Prut rivers

2.2. General characterization of the natural framework of the Moldavian Plateau

From a geological perspective, the Moldavian Plateau overlaps the Moldavian Platform (north and central sectors) and the Bârlad Platform (southern sector), both covered by a thick sedimentary cover composed of Cretaceous, Neogene, and Quaternary deposits (Băcăuanu et al., 1980). Differences in sedimentary evolution are directly reflected in the monoclinal structure and in the diversity of relief forms. In the northern sector, the incision of the Prut River into Cenomanian and Badenian deposits has exposed limestones, marls, and gypsum, which play an important role in controlling cuesta development and erosional resistance (Chițimuș, 2013; Niculiță, 2020) (Figure 5).

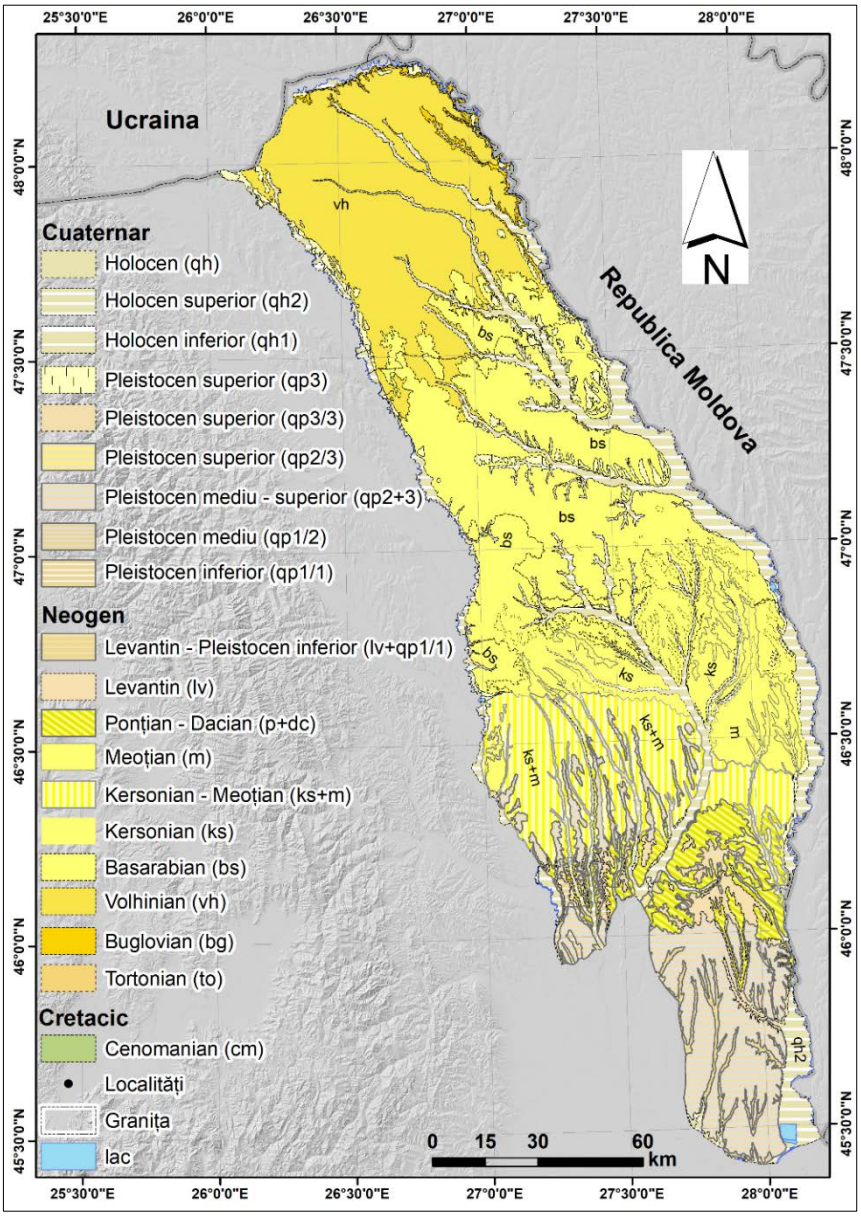


Figure 5. Geological map of the sector between the Siret and Prut rivers of the Moldavian Plateau (after the Geological Map of Romania, 1:200,000).

Basarabian deposits, widely developed in the Jijia Hills and the Tutova Hills, consist predominantly of marls and clays with sandy intercalations and are strongly affected by erosion and gullying (Macarovici, 1974; Ionesi et al., 2005). In the Tutova Hills and the Fălciu Hills, Meotian and Pliocene alternations favour slope instability and a high frequency of landslides (Ionesi, 1994), while in the southern sector thick loess-like deposits enhance geomorphological vulnerability (Munteanu, 2006; Niculiță, 2020).

Relief is dominated by cuestas and structural asymmetries, including the so-called "second-order asymmetry", associated with post-Volhynian tilting (Băcăuanu, 1968, 1973; Ioniță, 2000a). The pronounced fragmentation and the general eastward dip of strata are clearly reflected in the altitudinal distribution, with higher interfluves in the central-western sector and lower surfaces toward the east (Figure 6)

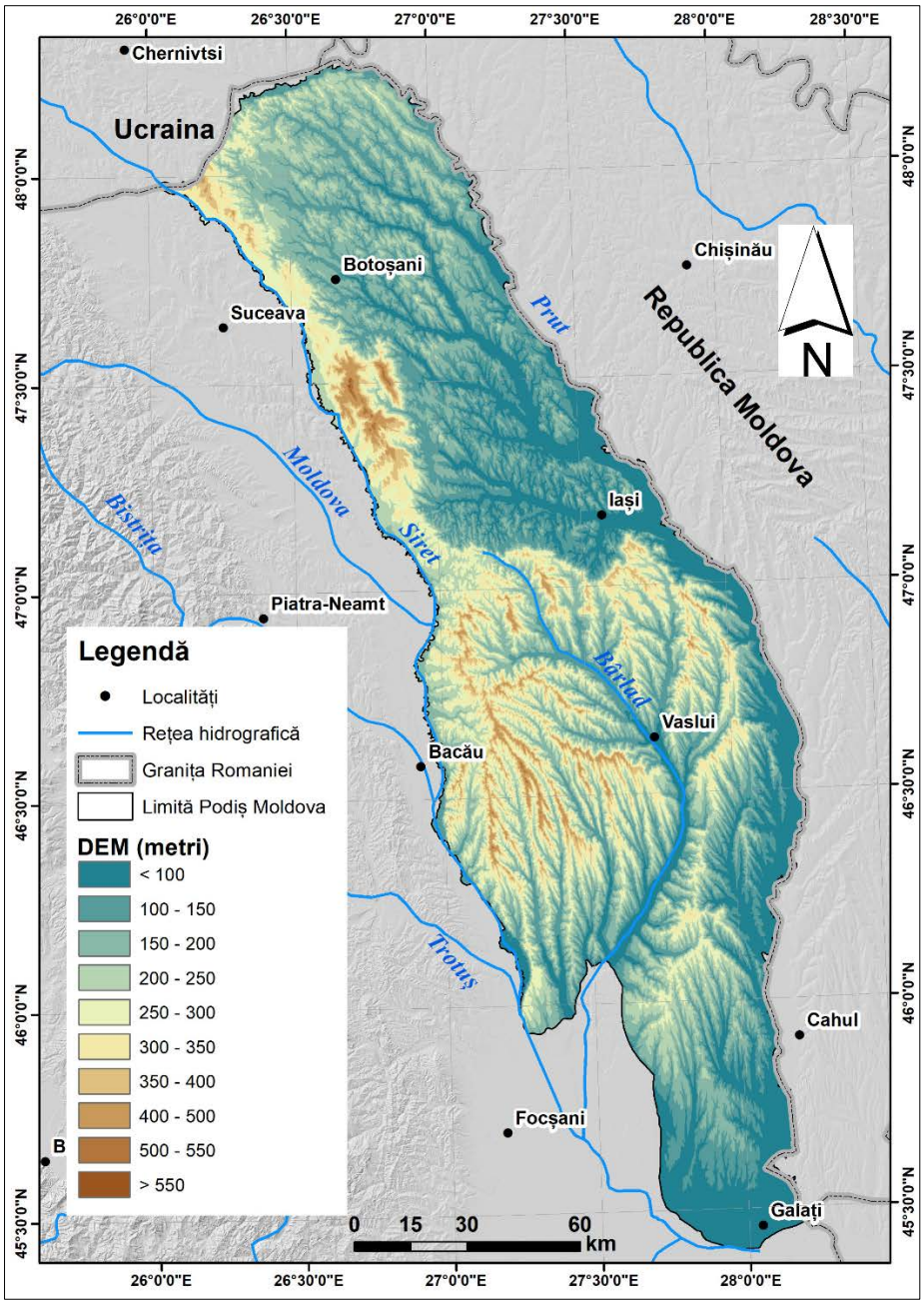


Figura 6. Hypsometric class representation of the Moldavian Plateau between the Siret and Prut rivers

Distribution of slopes highlights a contrast between the gentler eastern sector and the central and southern sectors, where steep slopes are associated with gullies and landslides (Figure 7). This configuration confirms the close relationship between geological structure, relief, and active geomorphodynamic processes (Ioniță, 2000; Niacșu, 2012).

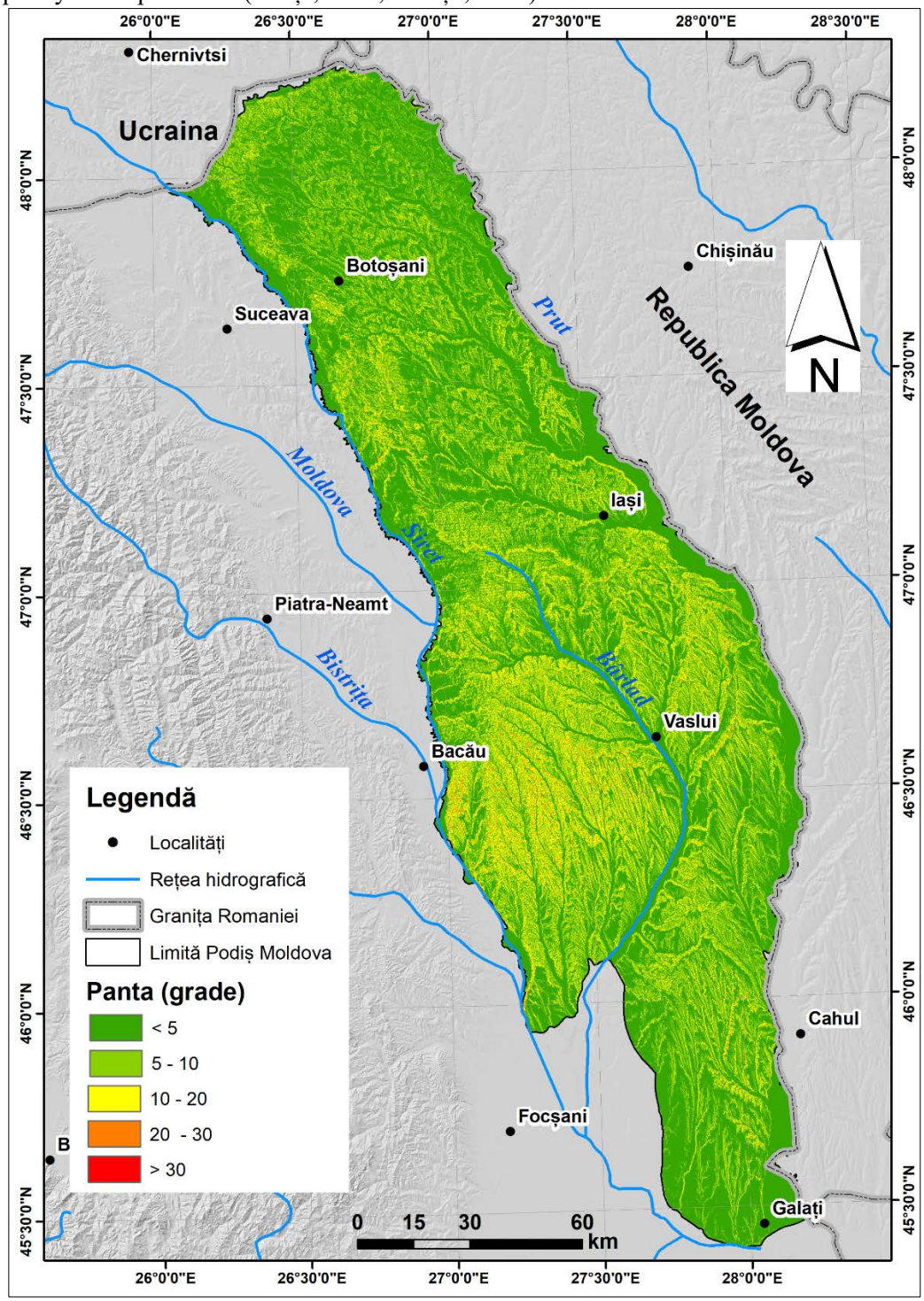


Figure 7. Slope distribution in the sector between the Siret and Prut rivers of the Moldavian Plateau (EU-DEM data, Copernicus, 2018).

From a hydrographic perspective, the analysed sector belongs in relatively balanced proportions to the Siret and Prut river basins, the valley network playing a major role in relief fragmentation and in the organization of the landscape (ABA Prut-Bârlad, 2016) (Figure 8).

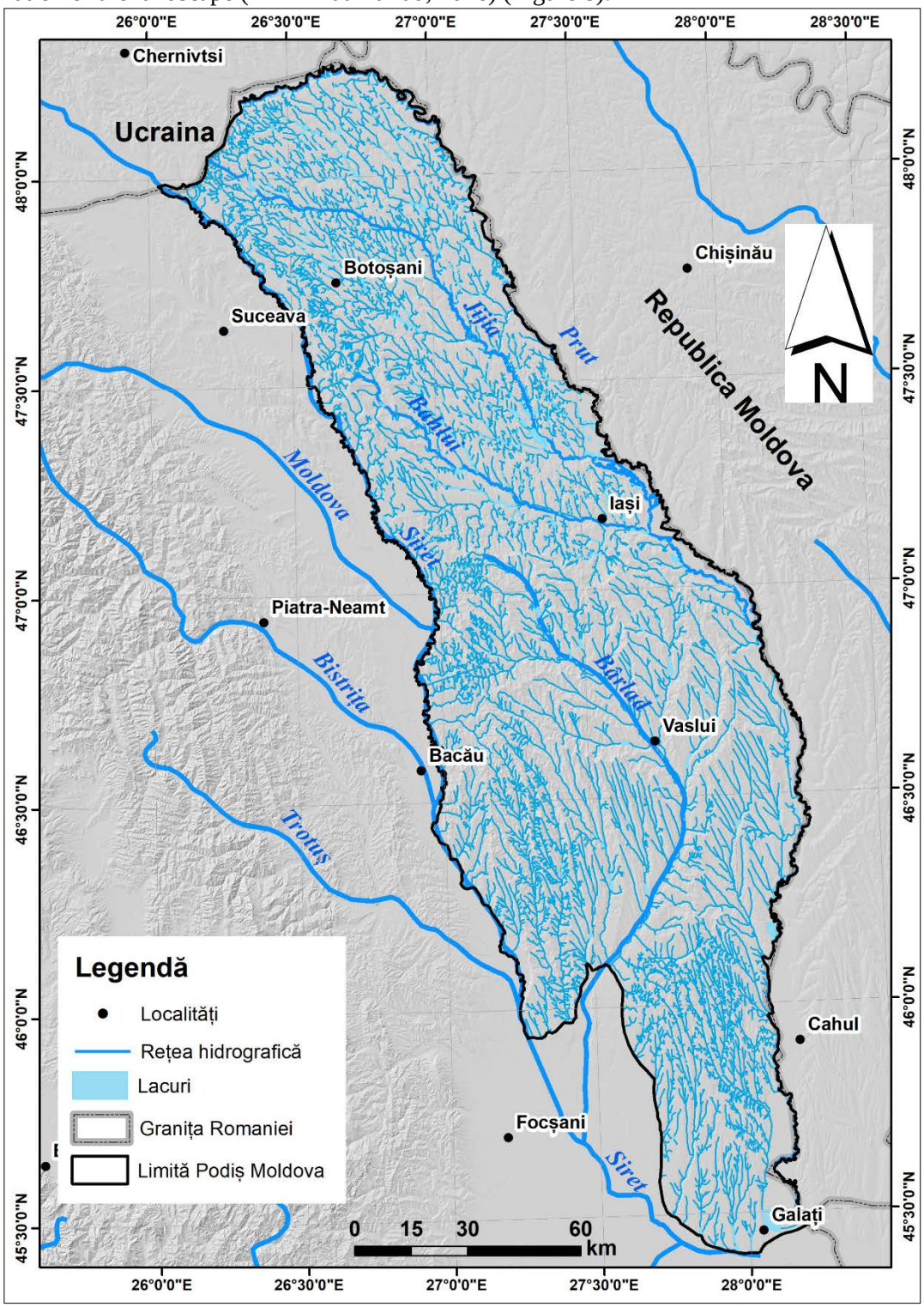


Figure 8. Hydrographic network of the sector between the Siret and Prut rivers (vector data processed from the ANCPI database - geoportal.ancpi.ro).

Distribution of soils reflects the correlation between lithological substrate, relief, and land use. Chernozems and phaeozems dominate the eastern and southern sectors, while eroded soils and gullies are frequent in the Tutova Hills, Fălciu Hills, and the Covurlui Plateau (Rădoane, 1995; Mărgărint & Niculiță, 2017) (Figure 9).

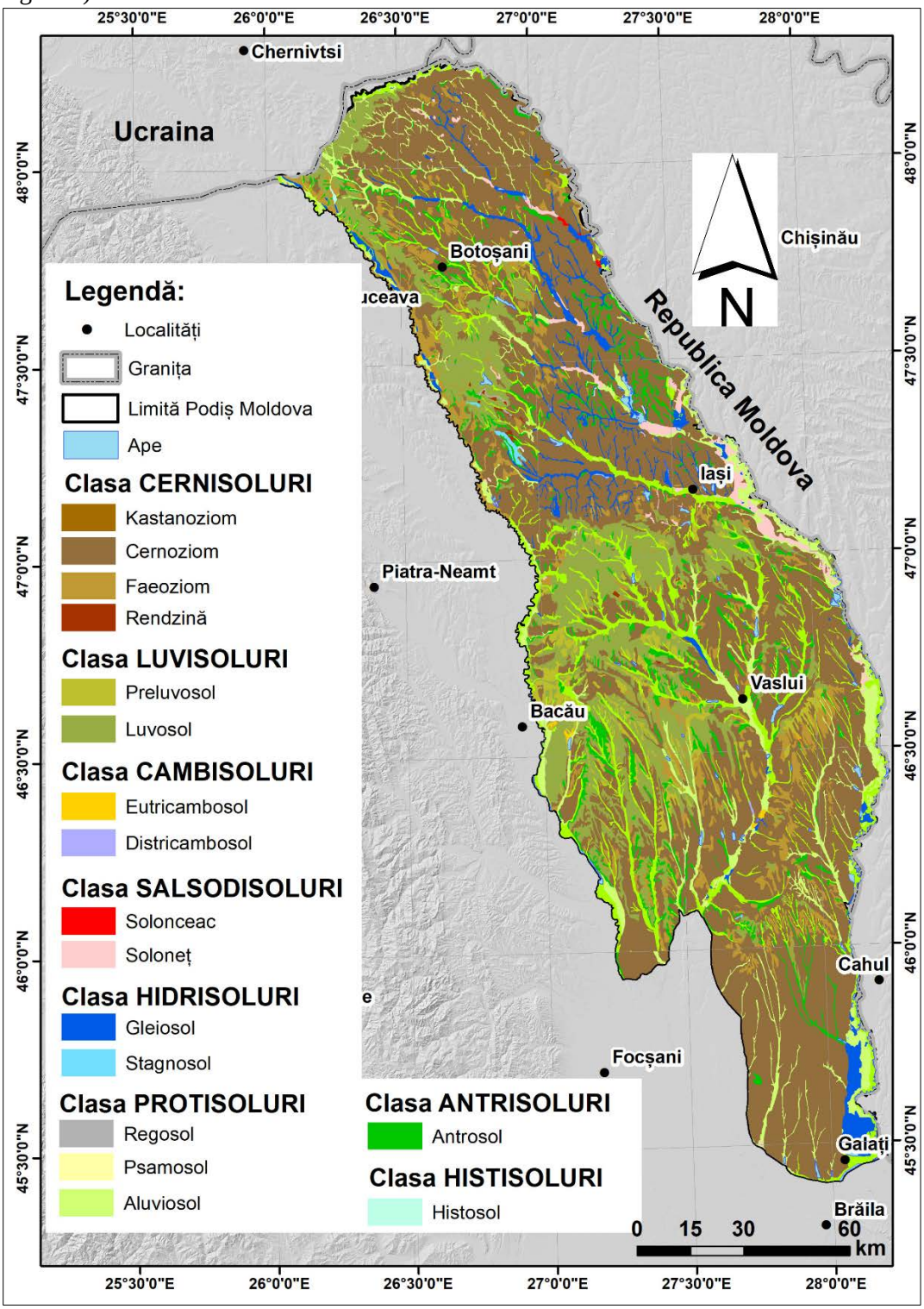


Figure 9. Soils of the sector between the Siret and Prut rivers of the Moldavian Plateau (after the Soil Map 1:200,000; legend standardization according to Secu et al., 2007).

Land use is dominated by agriculture, which explains the high anthropogenic pressure and the amplification of land degradation processes (Băcăuanu et al., 1980; Ioniță, 2000a; Stângă, 2016) (Figure 10).

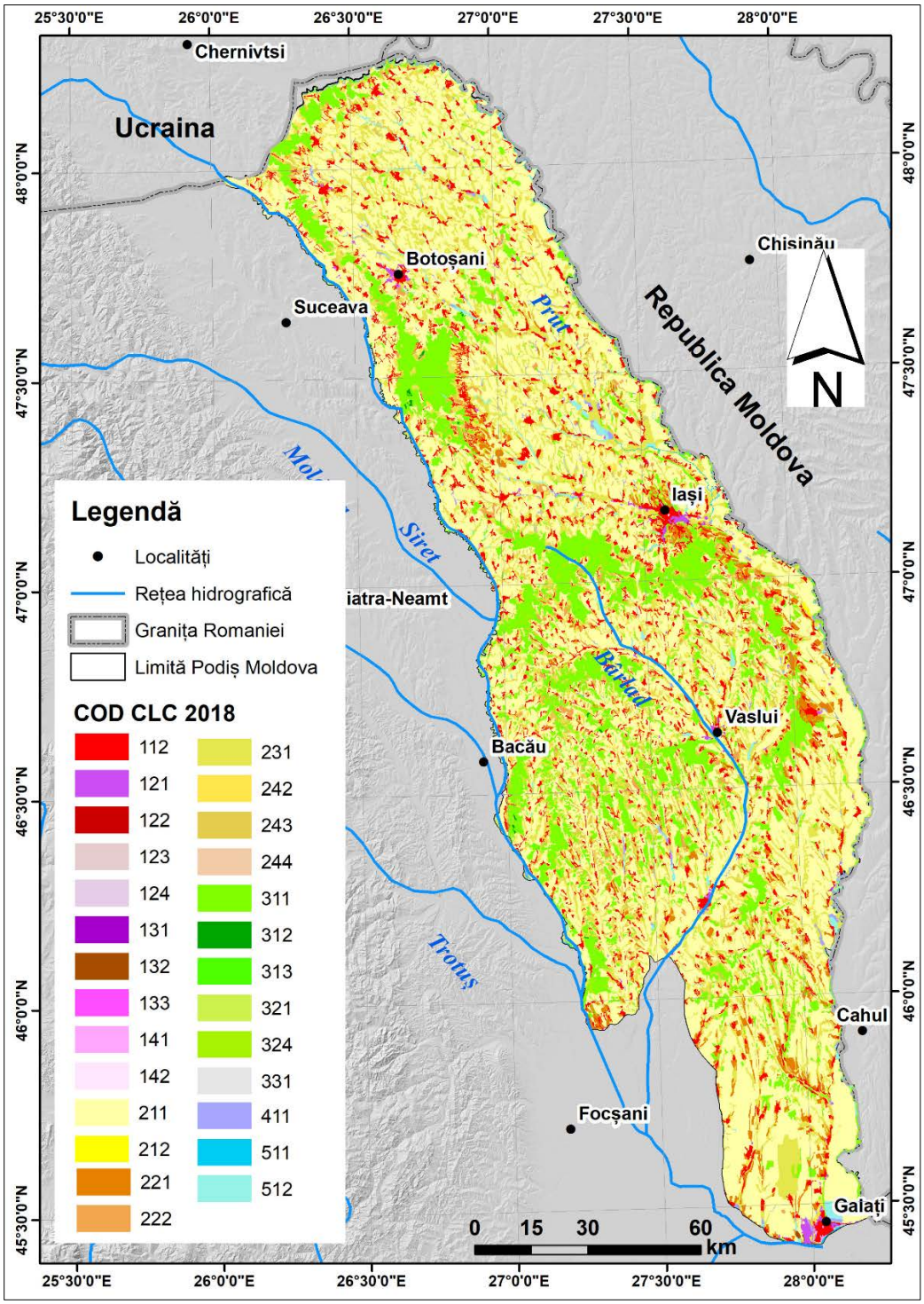


Figure 10. Land use in the sector between the Siret and Prut rivers of the Moldavian Plateau (Corine Land Cover 2018 data, European Environment Agency).

From the perspective of physical-geographical regionalization, the sector between the Siret and Prut rivers is included in several subregions and geomorphological units, delimited according to the physical-geographical regionalization proposed by Ungureanu (1993), which provides the reference framework for analyses dedicated to geomorphosites (Figure 12).

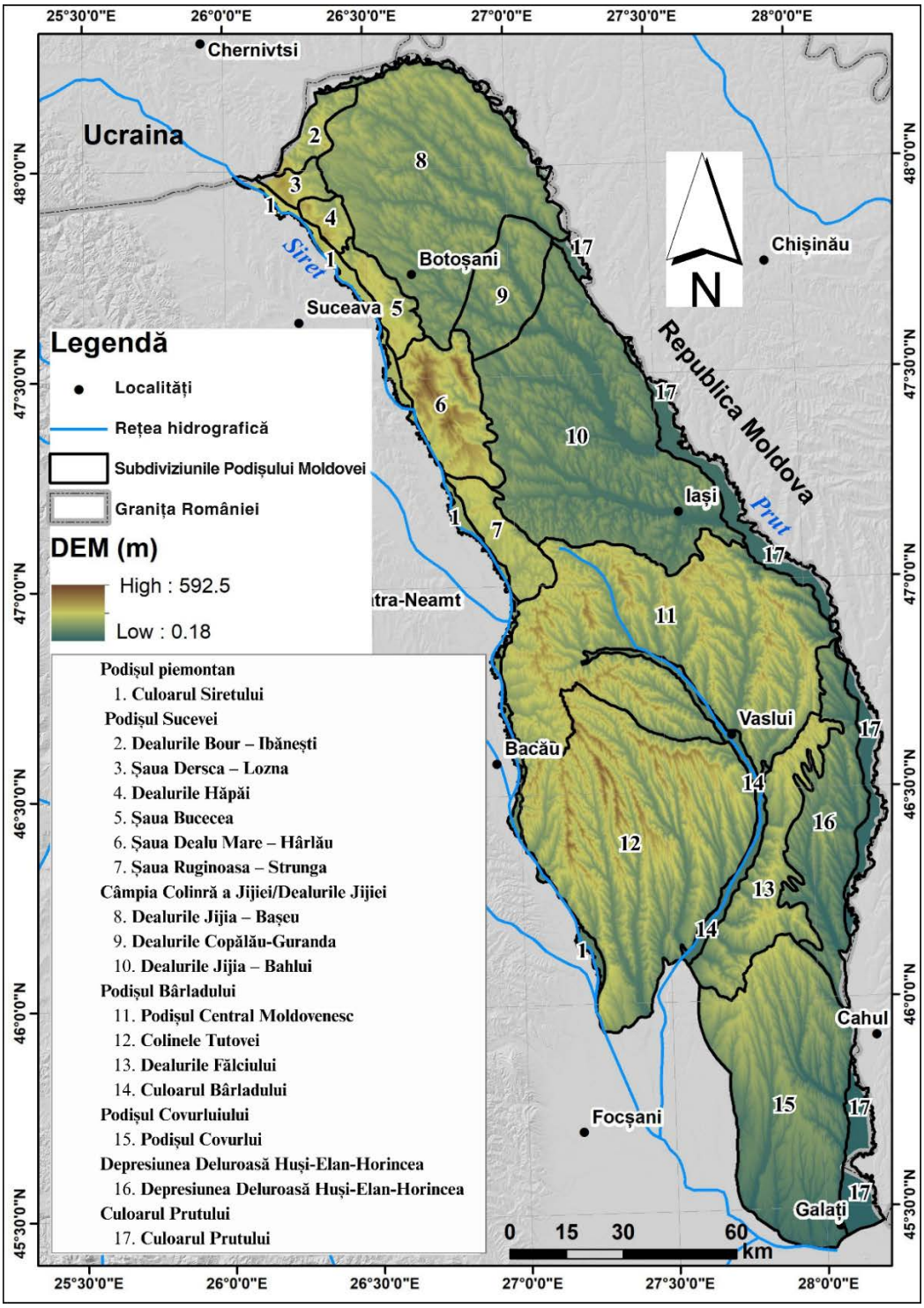


Figura 12. Subdivisions of the Moldavian Plateau between the Siret and Prut rivers (after Ungureanu, 1993)

2.3. Relationship between geosites (geological substrate, relief) and (geo)tourism in the Moldavian Plateau

The monoclinal geological structure of the Moldavian Plateau, together with the pronounced relief fragmentation, generates a wide variety of geomorphological forms and processes, conferring a high level of geodiversity to the region. This diversity is reflected both in landscape types and in land-use patterns and, implicitly, in the geotourism potential of the area.

A first relevant aspect is represented by the lithological substrate, composed of alternations of hard rocks (sandstones, calcarenites) and friable rocks (clays, marls, sands), which control the development of cuestas, steep scarps, and inclined surfaces. These lithological contrasts explain, on the one hand, the landscape attractiveness (panoramas, spectacular forms) and, on the other hand, the high vulnerability to erosion and landslides.

Relief is characterized by high and strongly fragmented interfluves in the central-western sector and by gentler surfaces toward the east, in the direction of the Prut River. This hypsometric variation generates clear differences in landscape and in tourism perception: areas with steep slopes are spectacular but more difficult to access, whereas areas with smoother relief are more suitable for tourism routes and for the cultural and historical valorization of the landscape.

Geomorphodynamic processes (gullies, landslides, accelerated erosion) represent both risk factors and resources with scientific and educational value. Intense gullying, especially in the Tutova Hills and the Covurlui Plateau, constitutes unique examples at the European level, which can be integrated into geotourism routes as interpretative sites illustrating the relationship between humans and the environment.

With regard to the interaction with tourism, landscapes resulting from this combination of substrate, relief, and geomorphological processes offer diverse opportunities, marked by the presence of a wide range of geosites with significant (geo)tourism potential, namely: (1) scientific geosites, where geological outcrops and active relief forms can be studied; (2) educational geosites, which allow the explanation of erosion and instability processes; and (3) cultural geosites, where historical values overlap with the natural landscape.

Thus, the relationship between the geological substrate, relief, and tourism highlights the complex character of the Moldavian Plateau: a territory that is geomorphologically vulnerable, yet characterized by a high potential for geotourism development and for strengthening geoconservation initiatives. This perspective justifies the need to compile an inventory of geomorphosites that captures both the diversity of natural elements and the possibilities for tourism and educational valorization.

2.4. Inventory of geomorphosites in the Moldavian Plateau

2.4.1. Geo(logo)sites

Based on the theoretical framework presented in Chapter 1, the category of geo(logo)sites designates those relief forms in which morphological expression is directly controlled by the structure and composition of the geological substrate. These sites reflect a functional correlation between geological genesis and geomorphological evolution, which confers scientific, educational, and heritage value upon them.

For documentation purposes, an inventory of geo(logo)sites within the sector of the Moldavian Plateau between the Siret and Prut rivers was compiled, based on extensive bibliographic research (Simionescu, 1902; Saulea, 1966; Brânzilă, 1997; Grasu et al., 2002; Ionesi et al., 2005, among others), complemented by information from the Lithostratigraphic Lexicon of Romania (Baltres., 2024) and by original interpretations derived from GIS processing.

The result consists of an inventory of 29 geo(logo)sites (Figure 13), belonging to a variety of lithological and stratigraphic types, which are detailed and systematized within the thesis: reference stratigraphic outcrops (e.g. Arg_01 – Cryptomactra clays), oolitic and biohermal limestones (Cal_01–Cal_03, Ool_01–Ool_02), sandstones with oolitic elements (Gre_01–Gre_03), cineritic tuffs (Cin_01, Tuf_02), sand and gravel deposits with stratigraphic and palaeoenvironmental value (Nis_01–Nis_05, Pie_01), and formations with relevant fossil content (Mic_01).

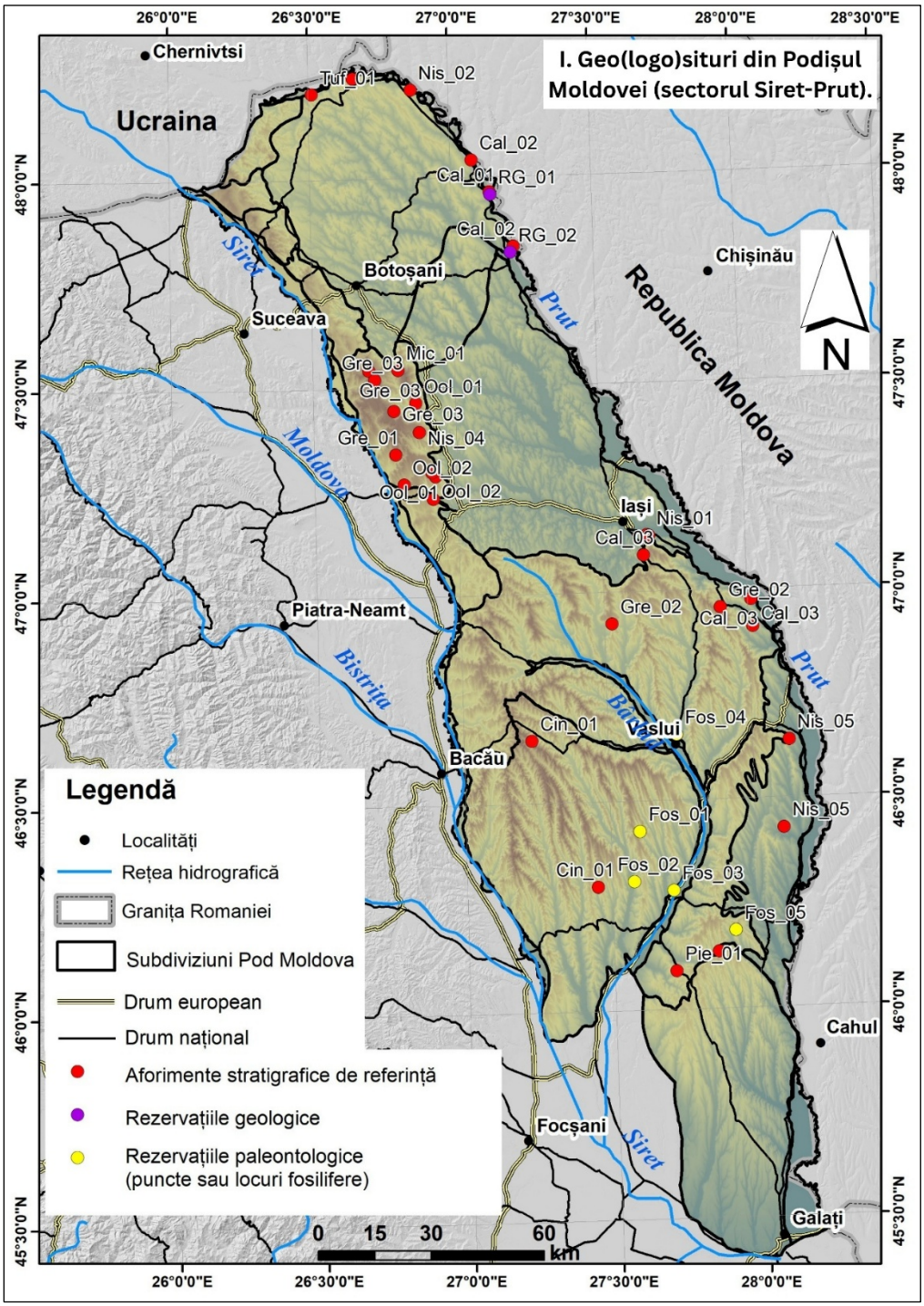


Figure 13. Distribution of geo(logo)sites in the Moldavian Plateau (Siret - Prut sector).

2.4.2. Geomorphosites

In direct relation to the relief forms associated with the main relief types characteristic of the studied area of the Moldavian Plateau, three major types of geomorphosites have been identified according to their origin: structural–lithological, fluvio-denudational, and anthropic.

2.4.2.1. Structural - lithological geomorphosites

Structural - lithological geomorphosites include relief forms whose expression is controlled by the monoclinal structure and by lithological contrasts, and are grouped into six types: (1) structural-lithological plateaus; (2) structural-lithological ridges; (3) cuesta scarps; (4) lithological scarps and gorge valleys; (5) grottos, caves, and karstic and calcareous scarps; (6) mud volcanoes. Within the Siret-Prut sector, 132 sites were inventoried, uniformly coded and organized into a GIS database, allowing geomorphological analyses and applications in geoconservation and geotourism. Their spatial distribution, illustrated in Figure 14, highlights the correlation between the major structural sectors of the Moldavian Plateau and the identified types of geomorphosites. Detailed category descriptions and tabular inventories are developed in the doctoral thesis.

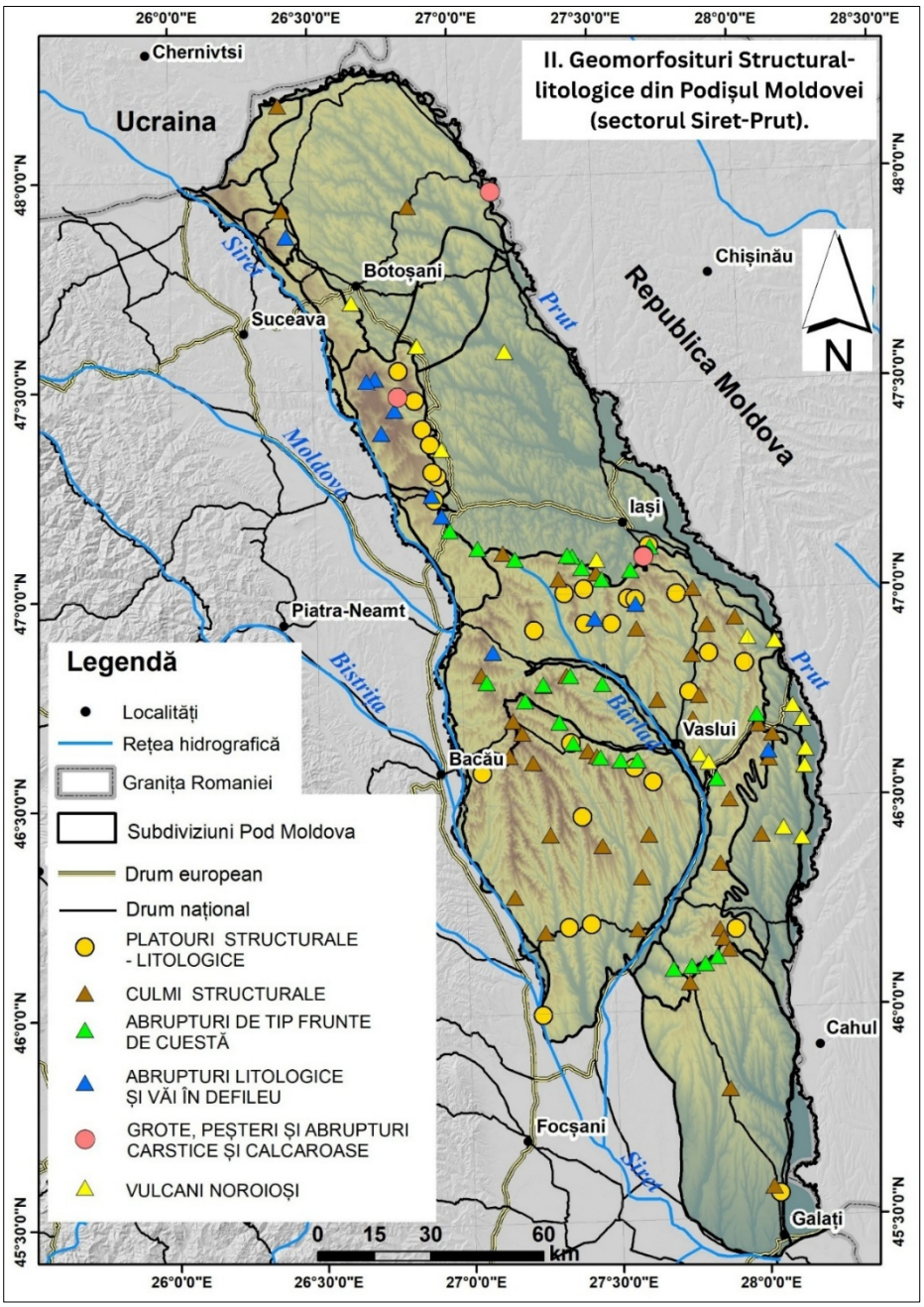


Figure 14. Distribution of structural-lithological geomorphosites in the Moldavian Plateau (Siret-Prut sector).

2.4.2.2. Fluvio-denudational geomorphosites

Fluvio-denudational geomorphosites include relief forms generated by surface and deep erosion processes, slope instability, and subsurface remodelling, and are grouped into four main types: (1) badlands ("pământuri rele"); (2) gullies; (3) landslides; (4) sinkholes (crovuri). Within the Siret-Prut sector, 102 fluvio-denudational geomorphosites were inventoried, with high concentrations in the Bârlad Basin, the Iași-Hârlău area, and the southern part of the plateau. Their spatial distribution, cartographically represented in Figure 15, highlights the close relationship between lithology, relief fragmentation, and the intensity of geomorphodynamic processes. Through their scientific, educational, and applied value, these geomorphosites represent an important component of the geomorphological heritage of the Moldavian Plateau, with a detailed analysis presented in the doctoral thesis.

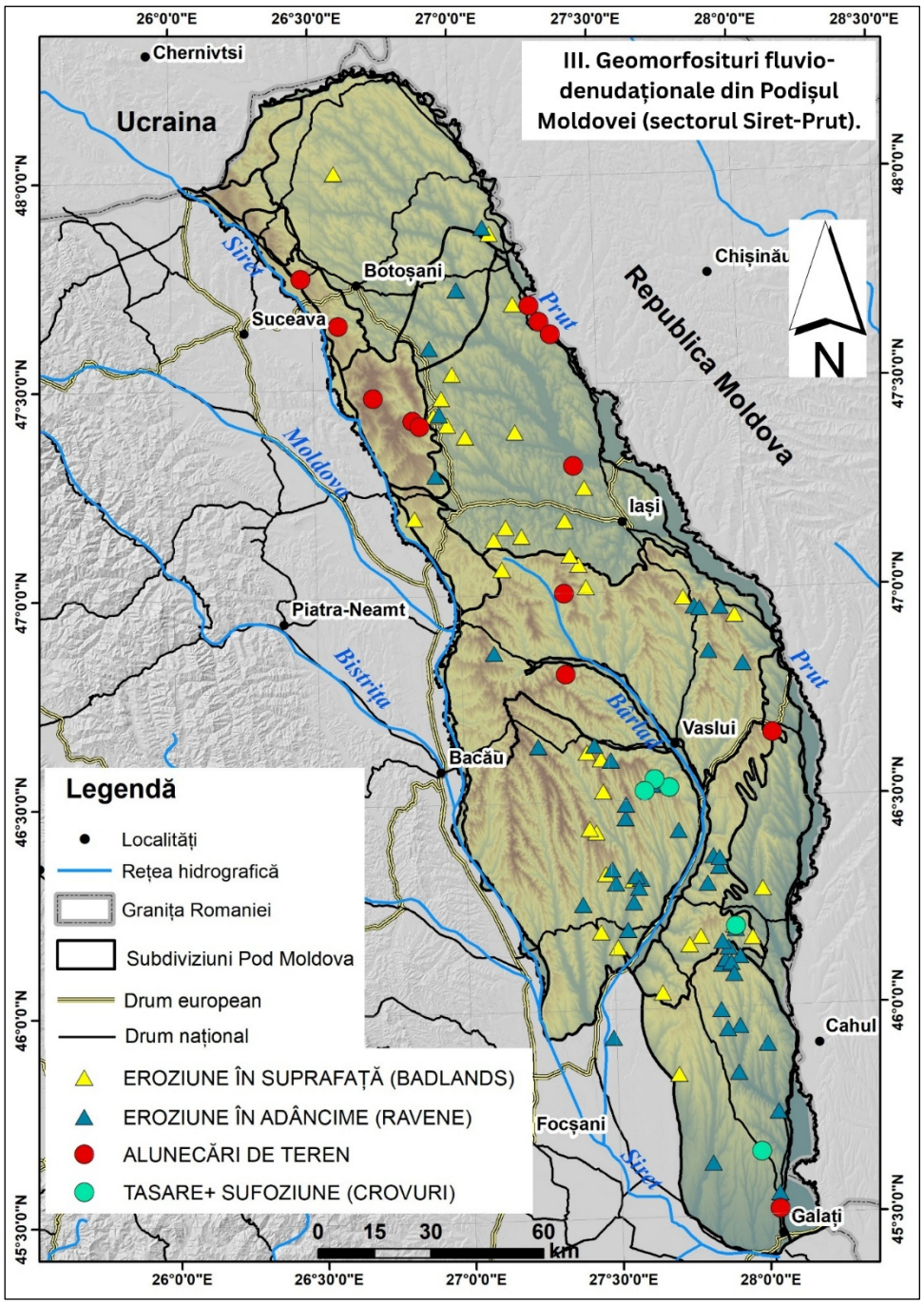


Figura 23. Distribution of fluvio-denudational geomorphosites in the Moldavian Plateau (Siret-Prut sector).

2.4.2.3. Anthropic geomorphosites

A special category is represented by anthropic geomorphosites, resulting from human activity, which through ordinary practices shapes and creates specific relief forms.

The cartographic representation in Figure 16 illustrates the distribution of the anthropic geomorphosites identified within the Moldavian Plateau. This category includes relief forms generated directly by human activity, preserved within the landscape and still visible today. Although they are not the result of natural processes, these elements were included in the geomorphosite inventory because they convey a dual significance: on the one hand, they mark the historical and cultural traces of human communities, and on the other hand, they contribute to the diversity of the present-day landscape. The map highlights three main types of anthropic geomorphosites: (1) sunken lanes (holloways); (2) tumuli and burial mounds;(3) earthworks and trenches.

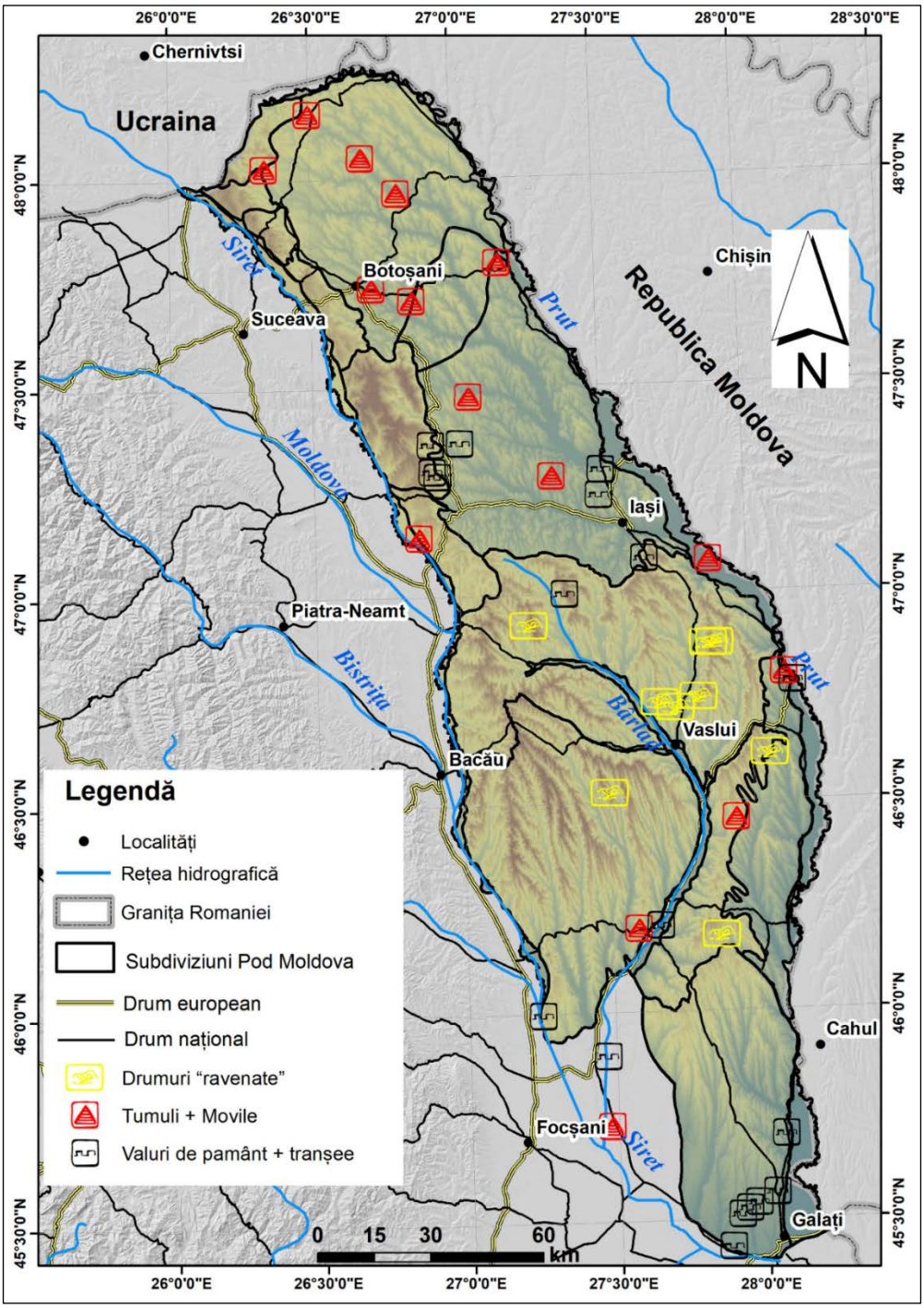


Figure 16 Distribution of selected examples of anthropic geomorphosites in the Moldavian Plateau.

A relevant example for understanding anthropic geomorphosites is provided by Botoșani County, where the map in Figure 17 highlights a remarkable density of tumuli, mounds, and archaeological sites, their number reaching several hundreds. The cartographic representation is based on data from the National Archaeological Record, managed by the National Heritage Institute.

It can be observed that tumuli and mounds (red points) are mainly distributed on interfluves and terrace margins, suggesting both their memorial or funerary role and their function as territorial landmarks. At the same time, archaeological sites (green points) confirm intense and long-term human occupation, making these forms an integral part of the contemporary landscape.

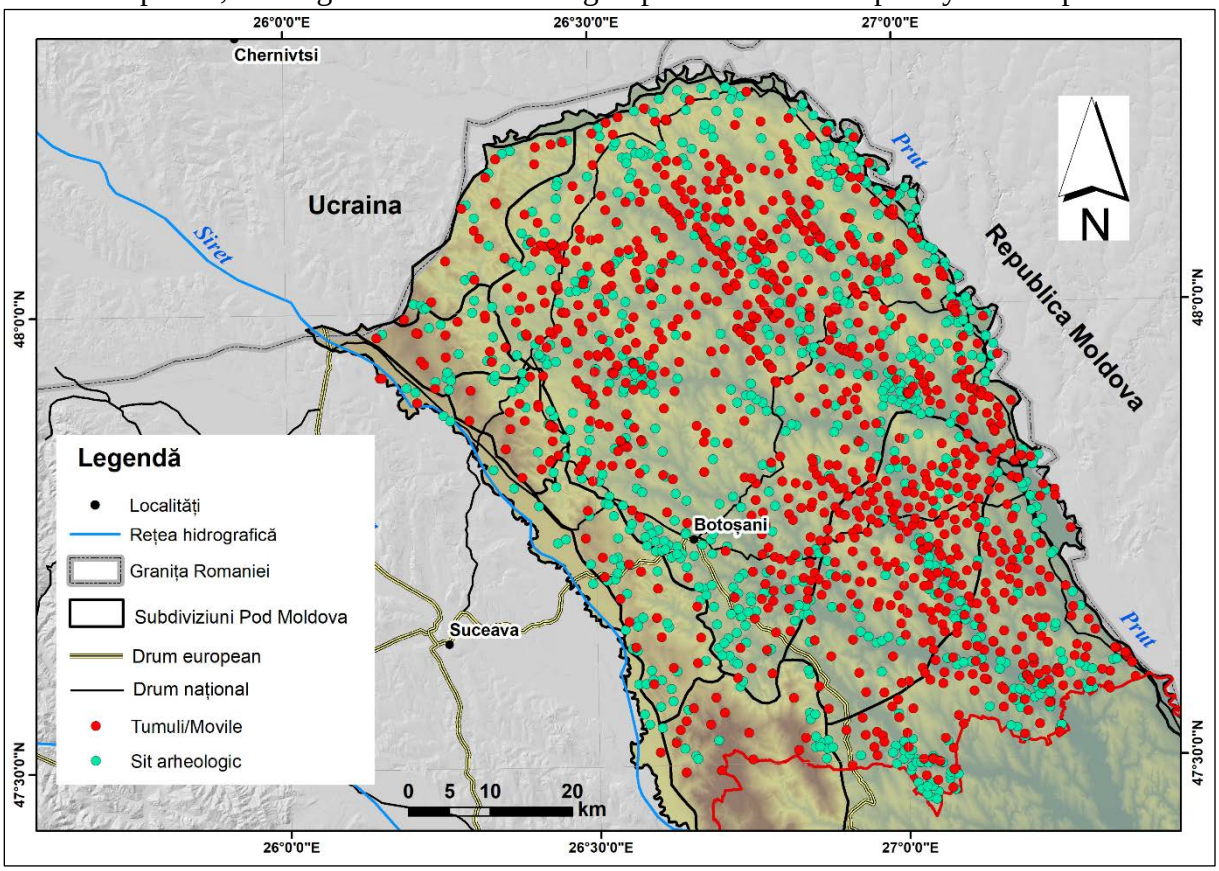


Figura 17. Distribution of tumuli, burial mounds, and archaeological sites in Botoșani County (after data from the National Heritage Institute,, https://map.cimec.ro/Mapserver/)

Thus, even though these forms do not belong to the realm of natural geomorphological processes, their inclusion in the geomorphosite inventory is justified by their cultural, historical, and landscape value. They offer new research perspectives as well as opportunities for the development of cultural tourism, for promoting local identity, and for strengthening the links between communities and the geographical space they inhabit. In this way, the chapter

Chapter 3: Geotourism valorization of the Moldavian Plateau. Case study: the Repedea geosite

3.1. Geographical setting and boundaries of Iași County

This subchapter delineates the spatial framework of the research and justifies the selection of the analysed sector. Iași County is located in north-eastern Romania, within the Moldavian Plateau, between the Moldova River valley and the Prut River valley, in a monoclinic structural context. Although the county has a broader administrative extent, the analysis is methodologically restricted to the area between the Siret and Prut rivers, considered more geomorphologically coherent and particularly relevant for the concentration of geosites. The main physico-geographical subunits and relief elements (cuestas, incised valleys, floodplains) are highlighted, as well as the fact that county boundaries combine natural criteria (the Prut River) and conventional criteria (northern and southern limits). The evolution of these boundaries is correlated with historical–administrative transformations, while the role of Iași Municipality is emphasized as a regional pole influencing territorial dynamics. Overall, the subchapter supports the idea that this natural and cultural framework constitutes a favourable basis for geotourism development..

3.2. Brief history of geographical research

This section provides a synthesis of the main stages and directions of geographical research concerning the natural and socio-human framework of the Iași area. Early milestones in geology and stratigraphy are presented, with particular emphasis on the major contribution of Grigore Cobălcescu (1862), which marks the beginning of modern Romanian geology through the study of the Repedea limestone and the elaboration of the first geological map.

Subsequently, the development of geomorphological studies is traced (terraces, structure, cuestas, fluvial dynamics and slope processes), along with climatological research (instrumental observations, regional syntheses), hydrological and hydrogeological investigations (rivers, lakes, water chemistry), botanical studies (phytogeography, forest and transitional vegetation), and pedological research (soil types and degradation processes).

Within the socio-human dimension, contributions addressing population, settlements, toponymy, economy, and transport are highlighted, outlining an integrated picture of the relationship between the natural environment and human organization.

The result is a solid scientific foundation for analysing geoheritage and geotourism potential.

3.3. Geotourism and natural geoheritage. Case study: the Repedea geosite

The analysis focuses on the Repedea geosite, approached as a representative element of the geoheritage of the Moldavian Plateau and as a case study for geotourism valorization.

3.3.1. Natural framework of the Repedea geosite

This section presents the geomorphological and geological context of Repedea Hill/Plateau, part of the “Iași Cuesta”, characterized by a strong altimetric contrast relative to the Jijia Plain and the Bahlui Valley. The Sarmatian deposits (oolitic and sandy limestones) are highlighted, together with their scientific importance, including the role of the site in defining the Repedea Formation and in the history of Romanian geology.

Repedea is also classified as a protected area (geological and palaeontological reserve, later extended to include an avifaunistic component), with its administrative protection structure mentioned through the delineation of distinct zones. From a morphological perspective, the site is organized into two major units - the scarp zone and the plateau zone - summarized in Figure 18.

The scarp zone concentrates geological outcrops, karst microforms (grottos, caves), and sectors with high vulnerability, while the plateau zone supports multiple uses, including education, recreation, and observation. At the same time, various anthropogenic pressures are identified (deforestation, illegal extraction, waste dumping, grazing), generating the paradox of a highly valuable yet degraded and insufficiently managed site.

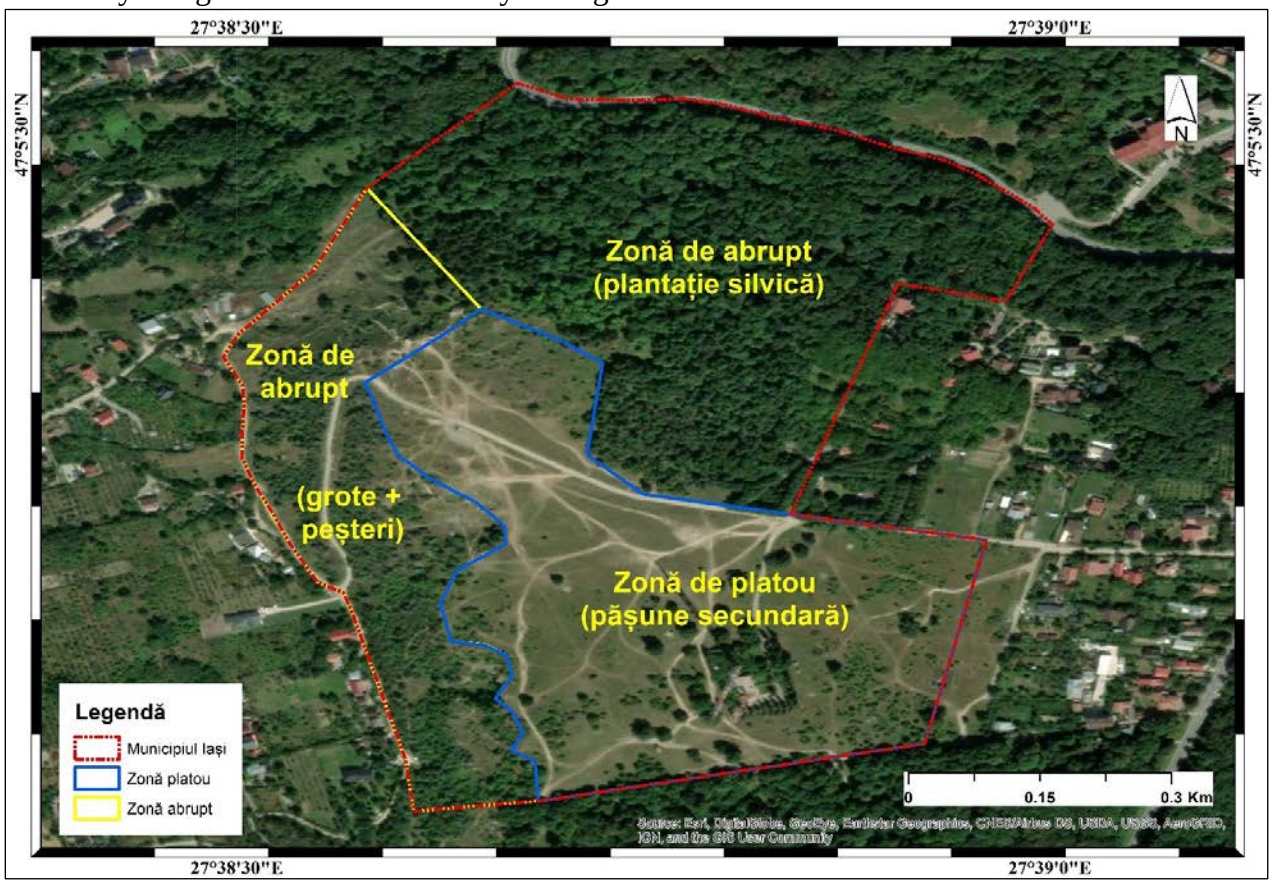


Figure 18. Morphological delimitation of the Repedea geosite: scarp zone (grottos and caves, forest plantation) and plateau zone (secondary pasture).

3.3.2. Geotourism potential of the Repedea site

The evaluation of the geotourism potential of the Repedea site is based on the analysis of geodiversity, biodiversity, and landscape value. The national scientific significance of the site and its educational role are emphasized, particularly due to its proximity to the urban environment, which facilitates thematic visits. The cultural dimension is also integrated: stone historically extracted from the site was used in representative buildings of Iași, directly linking the geological substrate to the city's architectural identity.

3.3.3. Accessibility elements and existing infrastructure

This section analyses the relationship between the degree of accessibility of the Repedea site and the current level of visitor infrastructure. The conclusions underline the necessity of sustainable infrastructure and coherent management in order for the geotourism potential of the site to become fully functional.

3.3.4. Proposal for the geotourism development of the Repedea site

Based on the obtained results, an integrated proposal for the geotourism development of the Repedea site is formulated. The general configuration is presented in Figure 19, which synthesizes the proposed functional organization. The proposal includes several main directions: improving accessibility (dedicated public transport line, organized parking facilities, alternative mobility), reorganization of roads and paths (reduction of motorized access, pedestrian and cycling routes), introduction of thematic trails (geological - geomorphological, biodiversity-related, cultural - anthropic), functional facilities (visitor centre/museum, services), controlled recreational areas, and sustainable viewpoints. Part of the analyses and development proposals included in this sub-subchapter have been previously valorized in a scientific publication (Anastasiei et al., 2025a).

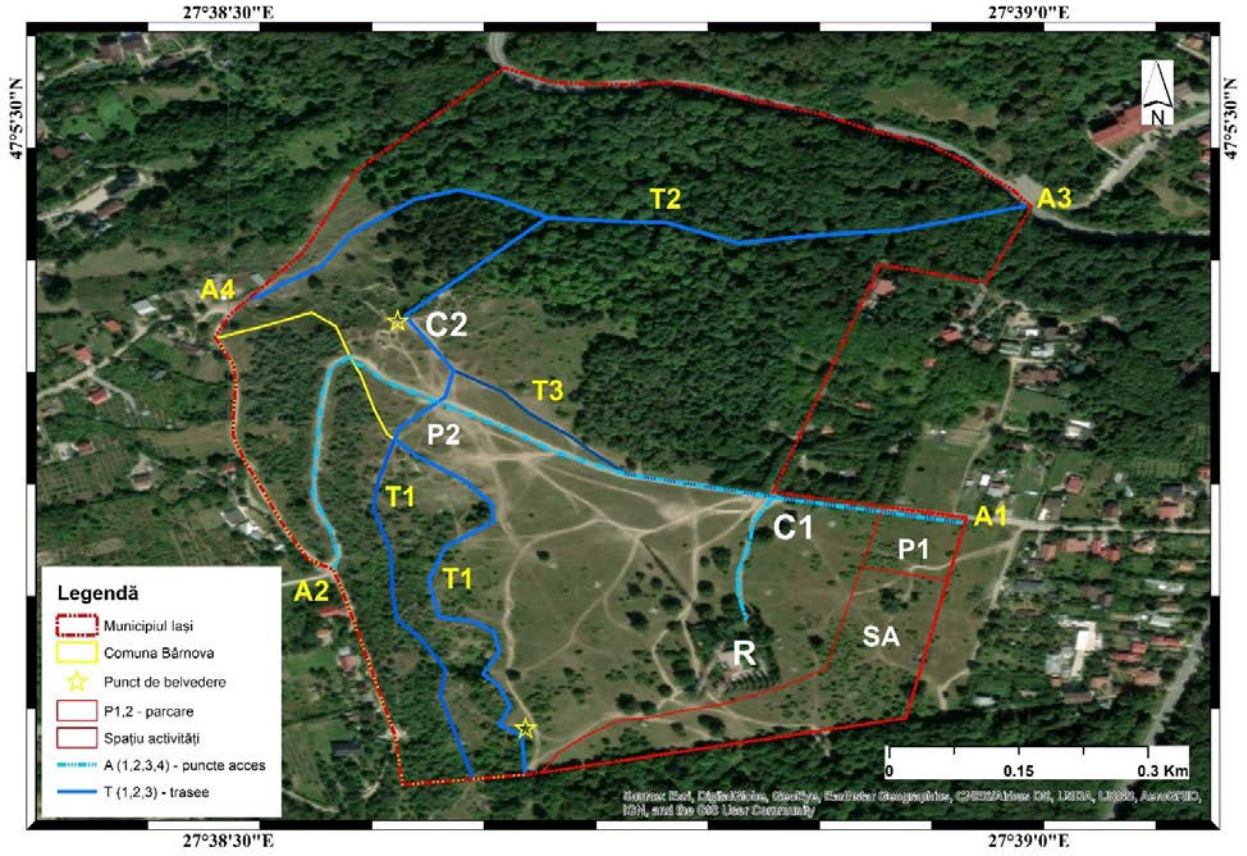


Figure 19. Proposal for the geotourism development of the Repedea site (functional organization sketch) (Anastasiei et al., 2025a).

3.3.5. Conservation and tourism management strategies

Although the status of protected area provides the Repedea site with a legal conservation framework, field reality reveals a series of vulnerabilities generated by anthropogenic pressure and the lack of integrated management. The identified issues include recurrent deforestation in the buffer zone, vandalism of information panels and viewpoints, and the absence of adequate visitor infrastructure. These dysfunctions highlight the contradiction between the scientific and tourism value of the site and its deficient management. In this context, the geotourism valorization of the Repedea site requires the definition of coherent conservation and tourism management strategies, which are formulated within the present thesis.

Chapter 4: Geotourism and urban geoheritage. Case study: Building stones as elements of cultural heritage in the city of Iași

Geological and geomorphological heritage is not limited solely to natural elements or spectacular relief forms, but also includes the materials used in traditional architecture and historical buildings. Cities, through their built structures, can become expressions of local geological resources, and their analysis offers relevant insights both for urban history and for the development of geotourism. Building stones thus represent a link between the natural environment and cultural heritage, illustrating the way in which the geological substrate has contributed to shaping urban landscape identity.

The city of Iași represents an illustrative example in this regard, being a cultural and historical centre in which materials derived from local geological formations-particularly oolitic limestone and oolitic calcareous sandstone-have been widely used in the construction of monuments, churches, and heritage buildings. The study of these rocks in the context of urban architecture allows not only an understanding of the relationship between geological resources and community development, but also the identification of new directions for tourism valorization, through the integration of geotourism and cultural dimensions.

This chapter is based on the results of a previously published scientific article that investigated the relationship between geotourism, dark tourism, and the use of building stones in the city of Iași (Anastasiei et al., 2025b). Within the present chapter, these results are adapted and integrated into a broader analysis specific to the field of geography, with emphasis on the role of building stones as elements of urban geoheritage.

4.1. Theoretical and methodological framework

This subchapter synthesizes the conceptual framework related to sustainable geotourism, geoheritage, and dark tourism, highlighting existing gaps in Romanian literature regarding integrated approaches to these forms of tourism in urban environments. The relevance of Iași Municipality as a case study is argued through the overlap between local geological resources (oolitic limestones and Sarmatian sandstones) and historical monuments, memorial spaces, and sites with strong symbolic significance.

4.1.1. Documentary basis and analysed materials

This section presents the bibliographic and cartographic sources used, together with historical, geological, geographical, architectural, and tourism-related data that formed the basis for analysing the relationship between building materials and urban heritage.

4.1.2. . Research methodology

The adopted methodology combines bibliographic analysis, field investigations, petrographic and mineralogical analyses, scanning electron microscopy (SEM) techniques, and geoinformatics methods (GIS, LiDAR). The general methodological framework is graphically synthesized in Figure 20).

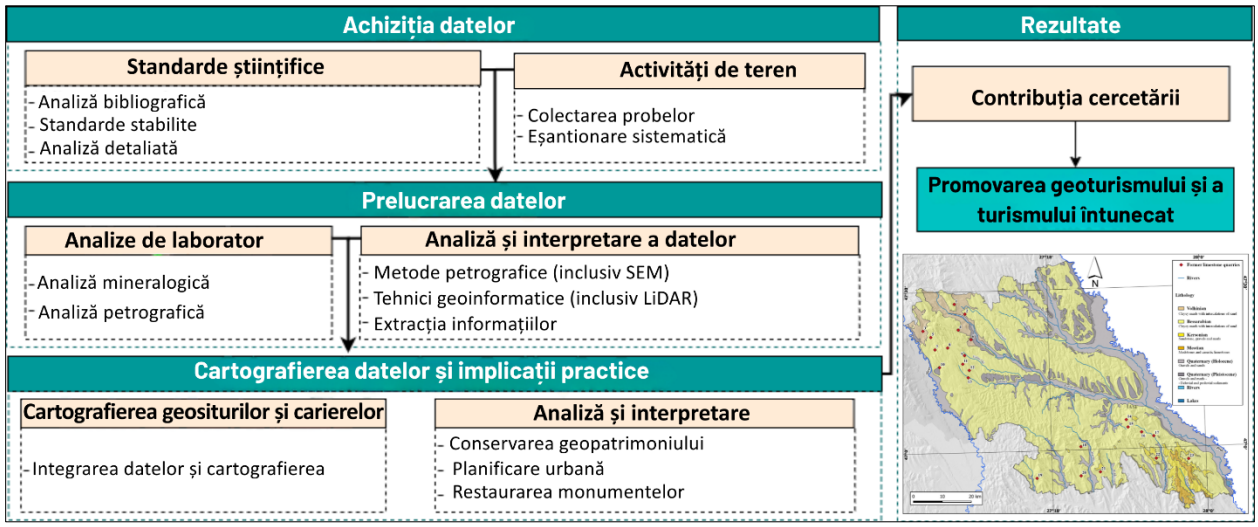


Figure 20. Methodological framework (Anastasiei et al., 2025b).

4.1.3. Applied analysis methods

This section details the methods used for the characterization of oolitic limestone, including macro- and microscopic descriptions of representative samples (Figure 21).

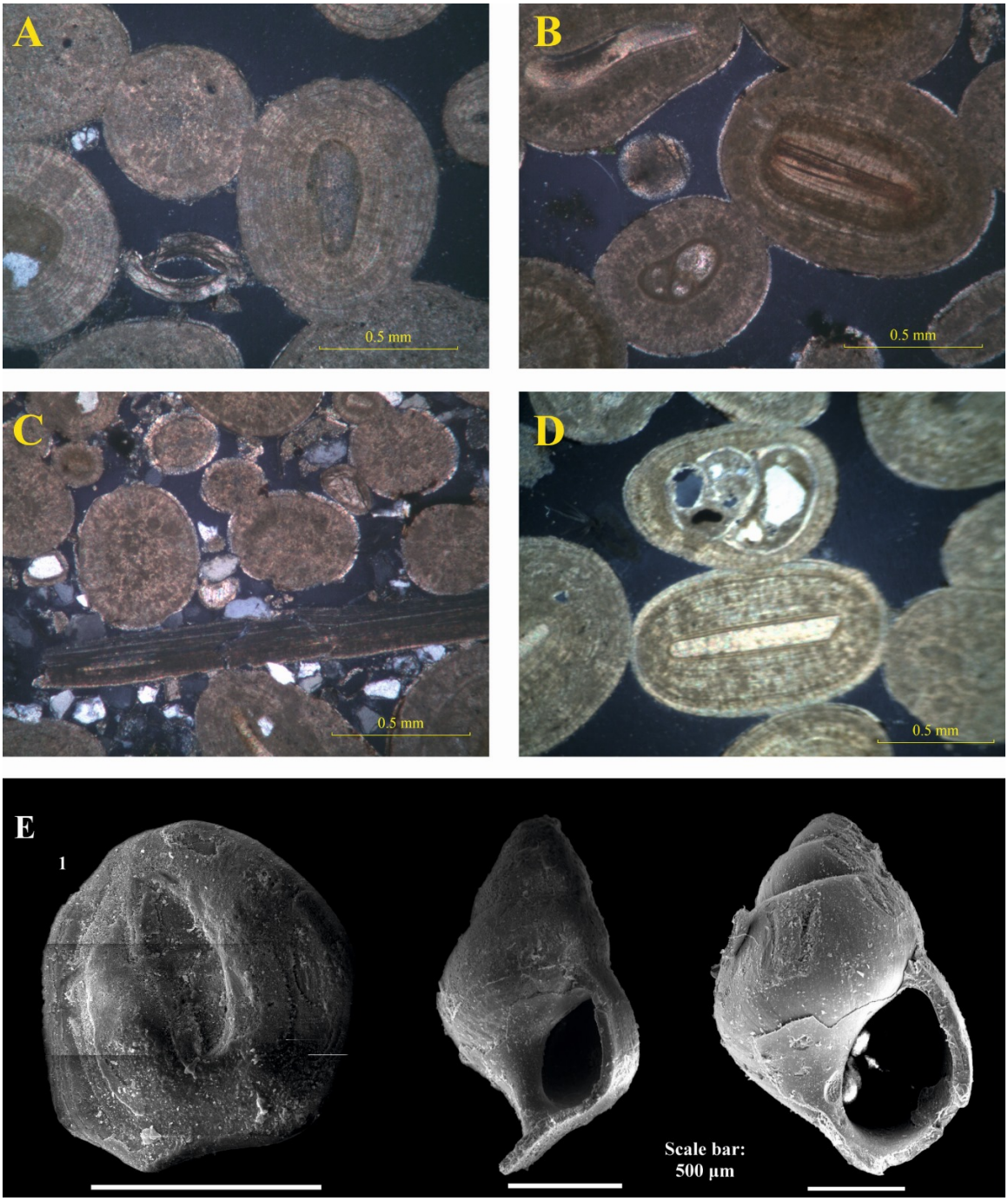


Figura 21. Images from thin sections of oolitic limestones from various locations in Iași County: (A) S1 - Răducăneni; (B) S2 - Bărboi Monastery; (C) S3 - Goian Hill; (D) S4 - Repedea Quarry; (E) SEM images of a Middle Miocene (Sarmatian) fish otolith (1) and micro-gastropod shells (2 - Hydrobia sp.; 3 - *Pseudamnicola sp.*) (Anastasiei et al., 2025b)..

In addition, the mapping of historical quarries and monuments built from local materials is presented, carried out with the support of LiDAR (Light Detection and Ranging) data (Figure 22).

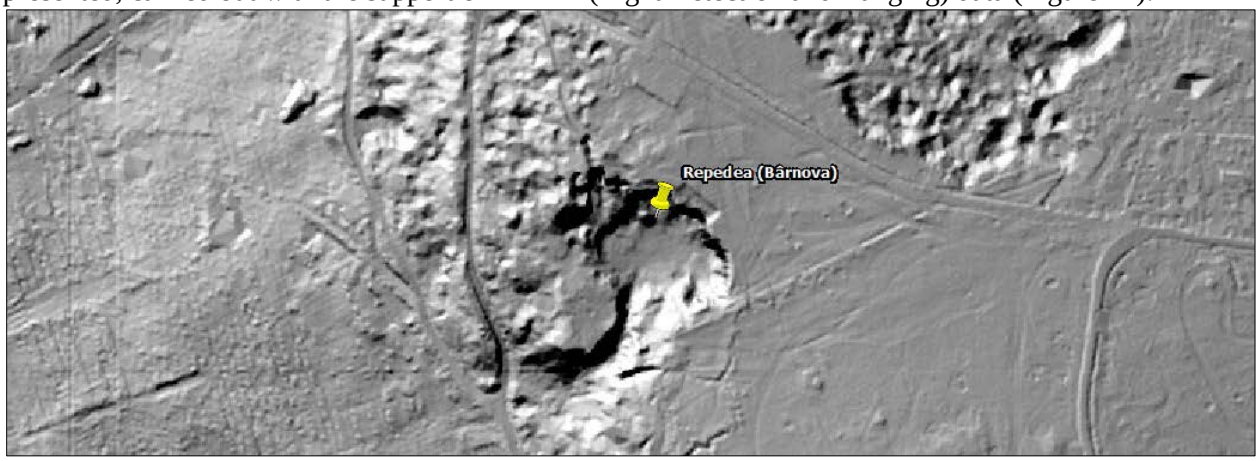


Figure 22. LiDAR-derived hillshade for the Repedea (Bârnova) area (Anastasiei et al., 2025b).

4.1.4. Conceptual approaches in geotourism and dark tourism

This subchapter clarifies the concepts of geodiversity, geoheritage, geosite, geomorphosite, and sustainable geotourism, as well as their relationship with dark tourism. The potential for integrating these two forms of tourism in urban environments is highlighted, particularly through the use of building materials as mediating elements.

4.2. Geographical and geological framework of the study area

The geographical and geological context of Iași Municipality is presented, with emphasis on the Repedea Formation (Middle Miocene), which represents the main source of oolitic limestone and calcareous sandstones used in historical constructions. The location of the city within the Moldavian Plateau is illustrated cartographically (Figure 23).

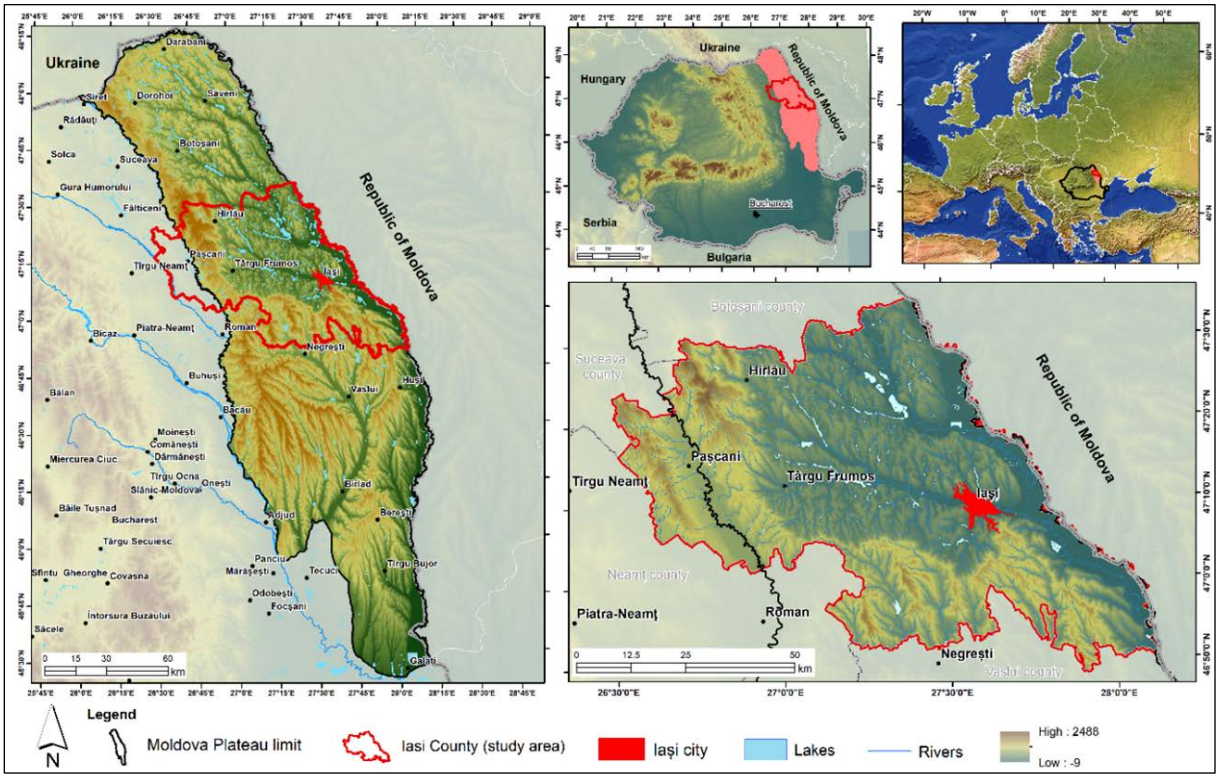


Figure 23. Location of Iași Municipality in Romania

4.3. Inventory of local building stones in Iași Municipality

This subchapter presents the results of the inventory of urban geosites, carried out through the systematic selection of monuments and historical buildings where the relationship between local lithic materials and the built heritage is evident. A total of 105 sites were identified and analysed, their spatial distribution and state of conservation being represented cartographically (Figure 24). The inventory provides an applied database for assessing building vulnerability and for developing urban geotourism routes.

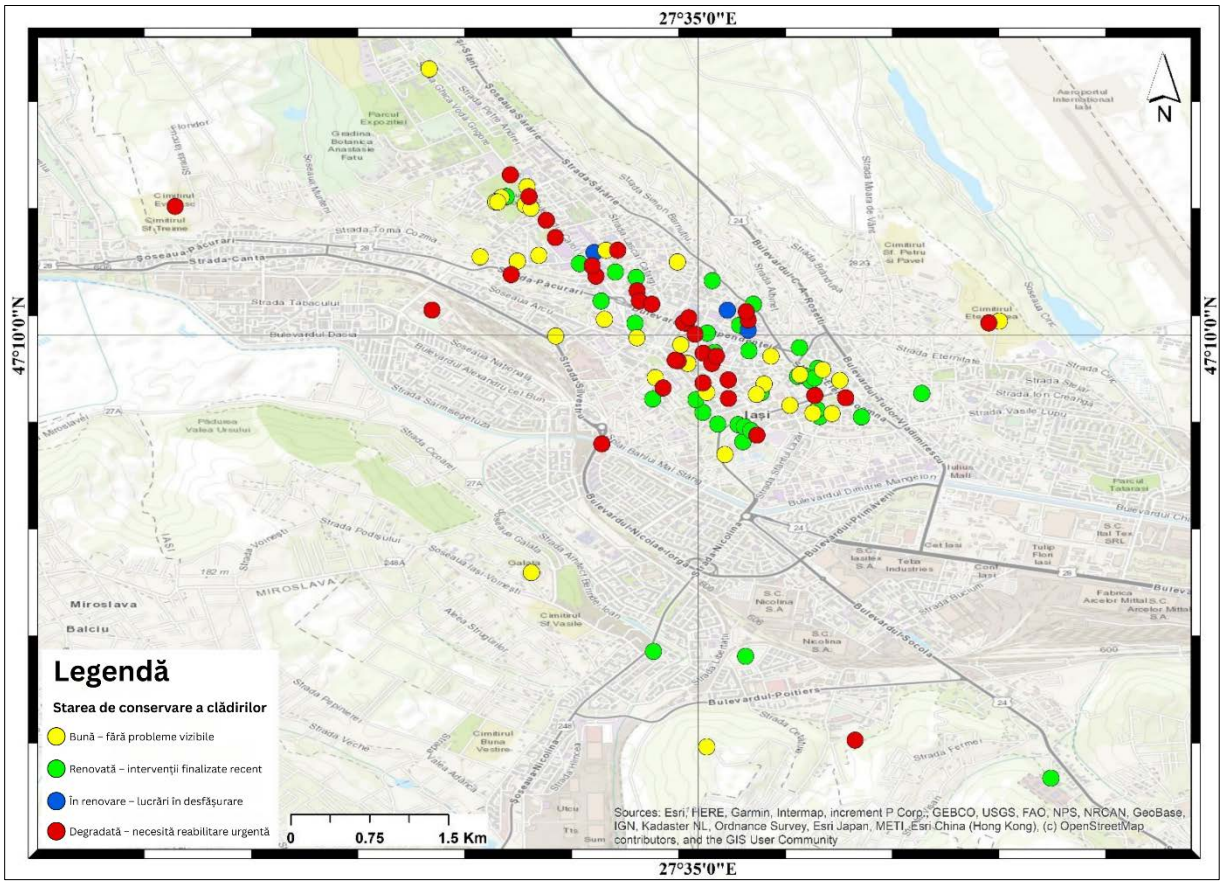


Figura 24. Urban geosites in Iași - distribution and state of conservation.

4.4. Geotourism and urban geoheritage in Iași Municipality

4.4.1. Identification of building material sources and database development

A total of 23 historical quarries of oolitic limestone and Sarmatian sandstones were identified, exploited primarily based on proximity criteria. Their distribution is synthetically illustrated through a thematic map (Figure 25), highlighting the role of Repedea Hill as the core of quarrying activities..

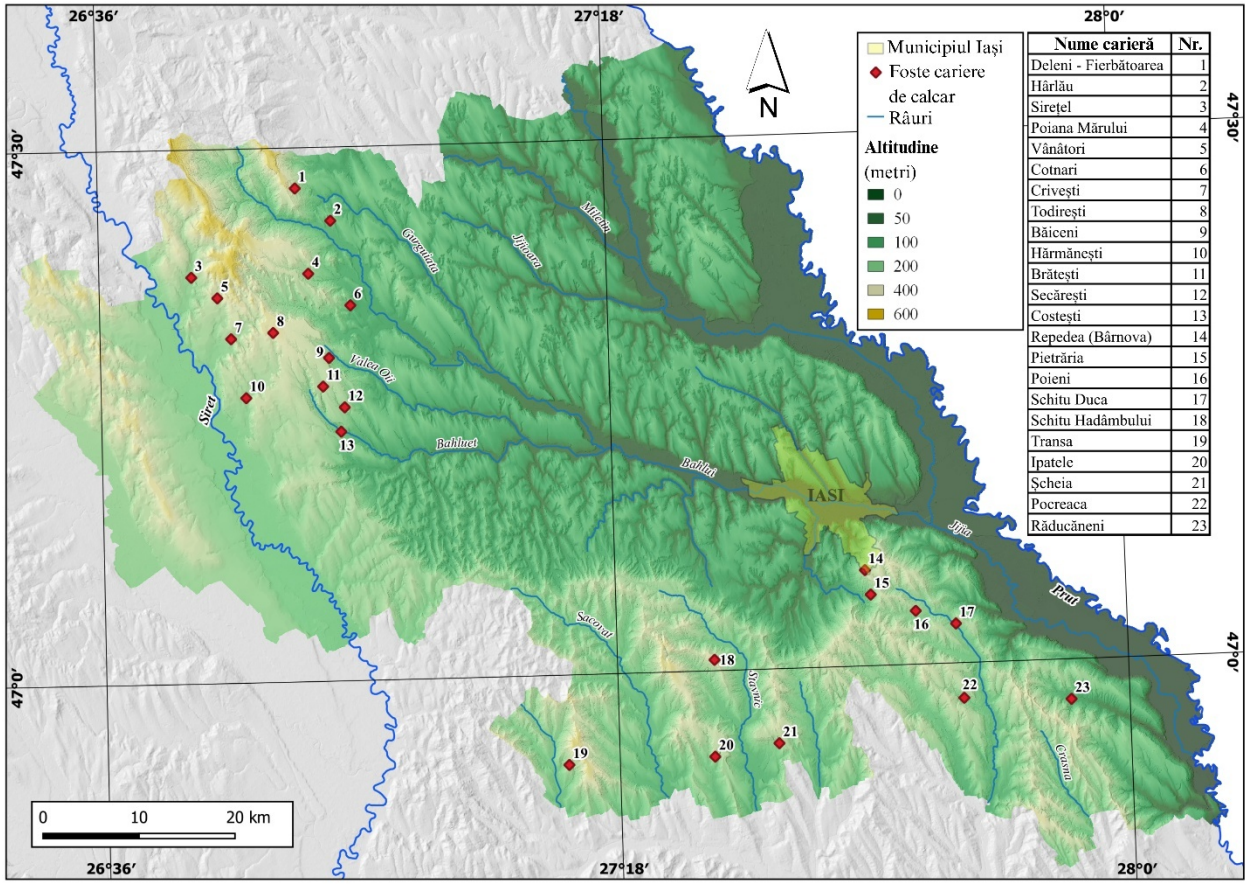


Figura 25. Spatial distribution of the 23 historical quarries (oolitic limestones and calcareous sandstones) in Iași County (Anastasiei et al., 2025b).

4.4.2. Comparative analysis of the 15 selected heritage sites with geotourism value

From the general inventory, 15 representative geosites were selected and comparatively analysed from the perspectives of geotourism and dark tourism. Their distribution within the urban space is illustrated cartographically (Figure 26).

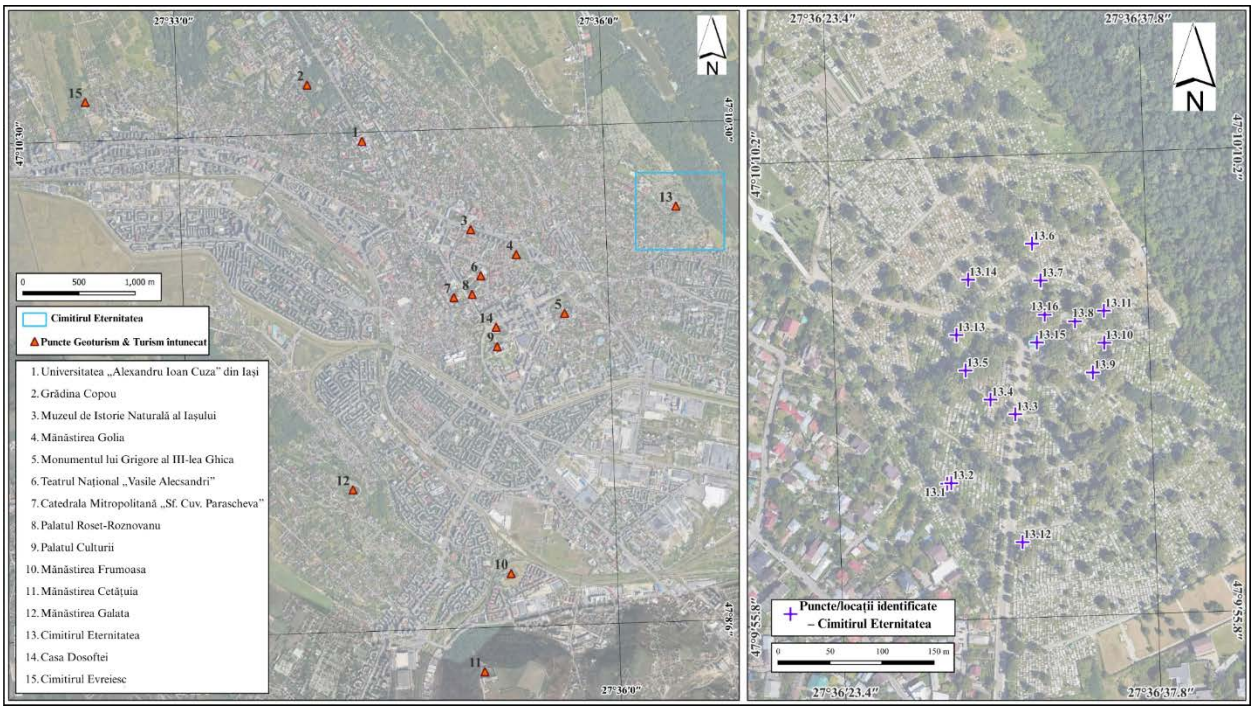


Figure 26. Spatial distribution of the analysed locations in the city of Iași (Anastasiei et al., 2025b).

4.4.3. Dark Geotourism Index - a quantitative approach

Dark Geotourism Index (DGI) is proposed and applied as a quantitative tool that allows the evaluation and ranking of heritage sites according to the degree of overlap between geotourism value and memorial–historical dimension, providing an objective and transferable comparative framework.

4.4.4. Geotourism and dark tourism within the heritage of Iași

This subchapter highlights the potential for integrating the built heritage of Iași into thematic routes that combine geological, historical, and memorial dimensions. The multicriteria evaluation of geotourism potential is graphically synthesized. Six core criteria were selected-aesthetic qualities, age, state of conservation, cultural importance, historical significance, and uniqueness and rarity-considered standard in geoheritage and heritage tourism research for determining site value. Each site was assigned a score from 1 to 10, where 1 indicates minimal relevance and 10 denotes exceptional value of international significance.

4.5. Conclusions

This chapter demonstrates that local building stones represent an important element of urban geoheritage in Iași, acting as a bridge between the geological substrate and the cultural identity of the city. The integration of geotourism with dark tourism, supported by the introduction of the Dark Geotourism Index, provides a robust framework for analysis and valorization, applicable both at the local level and in other historic cities. Detailed analyses, tables, and extended case studies are presented in the doctoral thesis and in the published article (Anastasiei et al., 2025b).

Chapter 5: Final conclusions and recommendations

The research conducted within the framework of the present doctoral thesis had as its central objective the identification and analysis of geomorphosites in the Moldavian Plateau and the evaluation of their geotourism potential, with the aim of demonstrating that this area - often regarded as marginal compared to mountainous regions - possesses resources of high scientific, educational, and cultural value. In achieving this objective, the thesis followed a logical and stepwise structure, beginning with theoretical and methodological foundations, continuing with practical applications at the level of the Moldavian Plateau, and culminating in detailed case studies - the Repedea site and the urban heritage of Iași Municipality.

From the introduction onwards, the importance of an interdisciplinary approach was emphasized, in which geomorphology was integrated with related fields such as geology, climatology, hydrology, pedology, as well as tourism and spatial planning. In this context, the analysis of geomorphosites was not limited to simple morphological descriptions, but aimed to capture the geotourism potential of relief, to integrate the obtained data into a unitary cartographic and digital database, and to substantiate proposals for tourism valorization and conservation.

The research methodology was characterized by complexity and diversity, including both classical geographical methods - direct and indirect observation, geographical description, analysis, and explanation - and modern approaches such as digital cartography, multicriteria evaluation, and the use of Geographic Information Systems (GIS). Field observations, complemented by the interpretation of satellite images and aerial photographs, enabled correlations between geographical reality and information obtained from secondary sources.

Bibliographic research established existing scientific benchmarks and opened the way for the formulation of original interpretations. Analysis relied on both quantitative criteria (altitudes, slope gradients) and qualitative criteria (functions and structure of the geomorphological system), while synthesis allowed the classification, hierarchization, and differentiation of the relief unit in relation to neighbouring areas.

Through this approach, the thesis aimed not only to identify and classify geomorphosites, but also to construct an integrated image of the geotourism potential of the Moldavian Plateau. Furthermore, the analysis served as a starting point for the broader geotourism valorization of the North-East Region of Romania, Iași Municipality, and adjacent areas, providing relevant data and interpretations for researchers as well as for specialists involved in tourism, spatial planning, and sustainable development policies.

In the **first chapter**, the research established a solid theoretical and methodological foundation by analysing the evolution and diversification of the concepts of geodiversity, geolandscape, geomorphosite, and geosite. These concepts were presented from a historical perspective and discussed in relation to biodiversity and ecosystem services, while the geolandscape was defined as an integrated expression of natural and anthropogenic factors, possessing not only scientific value but also aesthetic, educational, and cultural significance.

In particular, the chapter clarified the position of geomorphosites within geoheritage, demonstrating that they are not merely relief forms, but elements with scientific, educational, and

tourism value, resulting from processes of valorization and social perception. A genetic classification of geomorphosites specific to the Moldavian Plateau was proposed, allowing better typological structuring and adaptation to regional characteristics. At the same time, the term "geologosite" was introduced to highlight those sites in which geological and geomorphological values intersect, representing an original contribution applicable to geoheritage studies.

The chapter also included an analysis of the legislative and institutional framework relevant to the protection of geomorphosites and geosites in Romania. The main legal instruments for delimitation, conservation, and valorization of natural heritage were discussed, including protected area legislation, Natura 2000 regulations, and geopark initiatives. This overview demonstrated that, although a significant legislative framework exists, its practical application in the case of geomorphosites is often deficient, justifying the need for more coherent recognition and management strategies. Through these contributions, the first chapter outlined a robust theoretical and methodological basis supporting the applied research of the thesis.

In the **second chapter**, the proposed genetic classification of geomorphosites was directly applied, demonstrating its usefulness within the Moldavian Plateau. A comprehensive characterization of the natural framework was conducted, including geological, geomorphological, hydrographic, pedological, and land-use aspects that explain relief distribution and landscape vulnerability. The analysis showed that the monoclinal geological structure and the pronounced relief fragmentation generate a wide range of geomorphodynamic processes (erosion, gullying, landslides), making this area particularly relevant for geomorphosite studies and geotourism development.

A major result of this chapter was the inventory of geomorphosites in the Moldavian Plateau, based on extensive bibliographic research and original GIS processing. More than 310 sites with scientific, educational, and tourism value were identified and described, grouped into four main categories: geo(log)o-sites (34), structural–lithological geomorphosites (132), fluvio-denudational geomorphosites (102), and anthropic geomorphosites (42). Geo(log)o-sites included reference stratigraphic outcrops, biohermal limestones, sandstones, volcanic tuffs, fossiliferous deposits, and geological and palaeontological reserves, each demonstrating the close relationship between geological substrate and geomorphological evolution.

Structural-lithological geomorphosites comprised plateaus and ridges, cuesta scarps, lithological scarps and gorge valleys, grottos, caves, karstic and calcareous scarps, and mud volcanoes. Fluvio-denudational geomorphosites included badlands, gullies, landslides, and sinkholes (crovuri), illustrating the diversity of current relief-modelling processes. Finally, anthropic geomorphosites encompassed sunken lanes, tumuli and mounds, earthworks and trenches. Although not natural processes, these elements were included because they convey a dual significance: they mark historical and cultural traces of human communities and contribute to present-day landscape diversity through their direct impact on relief modelling.

By producing this unique regional inventory, the research highlighted both the diversity of geomorphosites in the Siret–Prut sector and their geotourism importance. The chapter demonstrated that the Moldavian Plateau, often perceived as marginal, possesses a natural heritage

comparable - by scientific and educational significance - to that of mountainous or karst regions.

The originality lies in applying the proposed classification, compiling the geomorphosite inventory, and correlating it with geotourism potential, providing a valuable analytical tool and a practical basis for regional development and conservation policies.

In the **third chapter**, the research focused on the geotourism valorization of the Moldavian Plateau through a detailed case study of the Repedea geosite. Recognized as Romania's first palaeontological reserve (1955), Repedea represents a scientific and educational reference point, characterized by complex Sarmatian stratigraphy, significant palaeontological diversity, and remarkable avifaunal biodiversity. An integrated analysis of the site's natural framework was conducted, correlating geological, geomorphological, biological, and cultural elements, resulting in a coherent understanding of its heritage value.

A key outcome was the evaluation of the geotourism potential of the Repedea site, identifying resources with scientific, educational, aesthetic, and recreational value. Accessibility, existing infrastructure, and tourism visibility were analysed, highlighting both opportunities and current limitations. The research proposed a geotourism development plan, including thematic trails, observation points, interpretive panels, and educational activities, aimed at enhancing site value and promoting responsible geotourism.

Furthermore, conservation and tourism management strategies were developed based on identified vulnerabilities: uncontrolled resource exploitation, anthropogenic pressure, and lack of coherent management. These proposals aim to transform Repedea from a vulnerable site into a model of good practice in geoconservation and geotourism, integrable into national and international heritage networks. Originality stems from the integrated approach combining geomorphological, tourism, and educational perspectives, and from proposing applied development and conservation solutions transferable to similar sites in the region.

In the fourth chapter, the research addressed the urban geoheritage of Iași Municipality through a systematic applied analysis. A major result was the identification and geolocation of 23 historical building-stone quarries, historically used for constructing monuments and heritage buildings. An inventory of monuments incorporating oolitic limestone and oolitic calcareous sandstone was then compiled, comprising 105 sites. This proposal of urban geosites was not arbitrary, but resulted from rigorous selection based on the List of Historical Monuments – Iași County (LMI-IS, 2015). Of 1,634 county-level monuments, 574 urban buildings were analysed, with the final inventory reduced to 105 following field verification and application of geotourism criteria.

To validate lithic materials, four samples were collected and analysed using petrographic, mineralogical, SEM, and LiDAR methods, providing relevant data on composition and vulnerability. From the 105 sites, 15 monuments were selected for detailed comparative analysis related to geotourism and dark tourism. The Dark Geotourism Index (DGI) was proposed as an original quantitative tool to assess geotourism and memorial potential, reduce subjectivity, and allow comparable ranking of urban sites. Results showed that Iași, through the diversity and value

of monuments built from local geological resources, holds strong potential to become a model for integrated valorization of urban geological, architectural, and cultural heritage.

In conclusion, this research **should not be regarded as a final outcome, but as a starting point for future studies**. The study demonstrated that the Moldavian Plateau and Iași Municipality possess valuable geotourism resources, but their full integration into regional development strategies requires continued research and practical implementation of results. A first step involves proposing thematic tourism routes across the plateau that highlight geomorphosite diversity and provide visitors with educational and recreational experiences. At the same time, initiatives should be launched to declare the **Repedea Palaeontological Reserve as a UNESCO Geopark**, ensuring enhanced protection and international visibility.

In the urban context, research results can support the development of thematic urban geotourism routes in Iași, linking geological heritage with cultural, architectural, and historical assets, and offering an integrated perspective on the city's identity. Moreover, the inventory of buildings constructed from local lithic materials highlights the need for prioritized restoration and conservation programmes to prevent irreversible degradation and preserve their value for future generations.

Therefore, the present thesis should be understood **as a foundational contribution**, establishing a new direction for research and valorization of **geoheritage in the Moldavian Plateau** (Romanian sector between the Siret and Prut rivers), which requires continuation through applied projects, interdisciplinary collaboration, and coherent conservation and promotion policies. Only through such an integrated approach can the region's natural and cultural heritage be fully recognized and valorized to its true potential.

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