

Main Gaps in Ecological Corridors Identification, Management, and Preservation in Danube-Carpathian Region

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Abstract: The Danube-Carpathian region represents one of the most preserved natural habitats for wildlife species in Europe. It is the last European great wilderness area, a stronghold for large carnivores, and home to the large remaining reserves of old-growth forests. Achieving ecological connectivity of the area is an inevitable part of its protection. Therefore, ecological corridors, which play a wide range of roles such as protecting endangered species and the biodiversity of territory, and securing its eco-connectivity while facilitating various ecosystem services, need to be thoroughly identified, managed and protected. That can contribute to avoiding landscape fragmentation and preserving the environment, including the endangered animal species. However, a comprehensive and coordinated ecological corridor identification, management, and preservation system within this region are missing, and the concerned countries meet with diverse problems when dealing with the issue. That creates one of the key problems in protecting these valuable natural areas. In order to identify the main gaps in the planning processes and tools related to the ecological corridors, broad analytical work has been undertaken supported by the questionnaire, carried out in the concerned 5 countries located in the Danube-Carpathian region. The paper's objective is to identify the gaps in the identification, management, and preservation of ecological corridors' involvement of the public in the processes such as integration of ecological networks into spatial planning in legal processes. The outcome of the study thus contributes to establishing an integrated approach for strengthening the capacity for identifying, managing, and protecting ecological corridors and helps to overcome the conflict between infrastructure development and wildlife conservation. The paper's novelty lies in the scope and breadth of the analysis, covering 5 Carpathian countries and stakeholders from various sectors under the umbrella of EU funded Interreg DTP Project.

Keywords: ecological corridors, Danube-Carpathian region, ecological connectivity, management.

多瑙河-喀尔巴阡地区生态走廊识别、管理和保护的主要差距

摘要：多瑙河-

喀尔巴阡山脉地区是欧洲野生动物物种保存最完好的自然栖息地之一。它是欧洲最后一个大荒野地区，是大型食肉动物的据点，也是剩余大量古老森林保护区的所在地。实现该地区的生态连通性是其保护的必然内容。因此，生态廊道在保护濒危物种和领土生物多样性、确保

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生态连通性、促进各种生态系统服务的同时发挥着广泛的作用，需要彻底识别、管理和保护。这有助于避免景观破碎化以及保护环境，包括濒临灭绝的动物物种。然而，该地区缺乏一个全面、协调的生态廊道识别、管理和保护体系，有关国家在处理该问题时遇到了各种各样的问题。这在保护这些宝贵的自然区域的背景下产生了关键问题之一。为了确定与生态走廊有关的规划过程和工具的主要差距，在位于多瑙河-

喀尔巴阡山脉地区的有关5个国家开展了调查问卷支持的广泛分析工作。本文的目的是找出生态走廊的识别、管理和保护方面的差距，以及公众参与诸如将生态网络整合到法律过程中的空间规划等过程中的差距。因此，该研究的结果有助于建立一种综合方法来加强识别、管理和保护生态走廊的能力，并有助于克服基础设施发展与野生动物保护之间的冲突。论文的新颖之处在于分析的范围和广度，涵盖了欧盟资助的多瑙河跨国计划项目下的5个喀尔巴阡山脉国家和各个部门的利益相关者。

关键词：生态走廊，多瑙河-喀尔巴阡地区，生态连通性，管理。

1. Introduction

Habitat fragmentation in the Danube-Carpathian region, one of the most preserved natural habitats for wildlife species in Europe [1], is fast and increasing. ConnectGREEN project aims to improve the ecological connectivity between natural habitats of this area to cope with the issue [2]. That is especially aimed at locations of international relevance, including Natura 2000 sites and other protected area categories in the ecoregion.

With a continental reach, these environments provide some ecosystem services. Therefore, their protection is in the interest of all stakeholders in the territory [1].

Identification of main gaps in ecological corridors identification and preservation within the Danube-Carpathian region is part of several deliverables of the ConnectGREEN Project. These include:

- Methodology for identifying ecological corridors;
- State of the Art Report on the existing planning systems and their application for ecological corridor identification and management;
- GAP analysis report on the identification of the needs for improving the planning processes and tools [1];
- Set of recommendations developed together with spatial planners to avoid/minimize fragmentation of ecological corridors and Natura 2000 sites;
- Ecological connectivity related database under the CCIBIS;
- Database with all relevant spatial information in each pilot site;
- Maps with the distribution of target species, core areas, ecological corridors, and critical barrier

sites in each pilot area;

- Strategy on the identification, preservation, and management of eco-corridors [2].

The project aims to increase the capacity for identification, management, and preservations of ecological corridors and help overcome the conflicts between infrastructure development and wildlife conservation in the largest, last remaining strongholds for the large carnivore species of the Danube-Carpathian region.

Therefore, it was important to answer the question: What are the main gaps in ecological corridor identification and preservation within the Danube-Carpathian region to fulfill this goal? In addition to the analytical work of an international team of experts and numerous interviews with representatives from the nature protection professionals in respective countries, a questionnaire was designed and distributed to the concerned 5 countries - the Czech Republic, Hungary, Serbia, Slovakia, and Romania.

As an outcome, gaps in policy frameworks related to ecological corridors identification, management and preservation, public involvement in the processes, and gaps in the integration of ecological networks into spatial planning were identified. This analysis provides valuable data that serve as a base for the later definition of recommendations and strategies to minimize fragmentation within the Carpathian ecoregion and maintain crucial biodiversity hotspots and valuable ecosystems on the continent.

2. Conceptual Background

Management of ecological corridors became one of the most intensively discussed common fields of interest in recent years among experts from spatial

planning, urban ecology, and landscape ecology. The conflict between decreasing natural and semi-natural areas and breaking up large patches of native vegetation into smaller, isolated ones has existed for a long time. However, the vast population growth and demand for natural resources or the fragmentation process nowadays have accelerated. These phenomena threaten certain species with extinction, and ensuring balanced spatial development through appropriate management of ecological corridors is becoming a pressing issue.

For the narrow focus of the term corridor, it would be more appropriate to talk about networks, connectivity, or linkages areas. The landscape is always in motion, matching together processes of spatial integration and spatial fragmentation represented by spatial development, infrastructure and capacity building, agricultural processes, and other human activities. Those processes influence the landscape resilience and biodiversity balance. The term connectivity can explain how organisms move within the environment or habitat patches. That is allowed by the spatial arrangement and the quality of individual elements in the landscape [3]. These elements, forming ecological networks, represent biotic interactions in an ecosystem. Here, species (nodes) are connected by pairwise interactions. Connectivity within the landscape is one of the central topics and concerns in ecology and planning in general [4]. It secures an optimal utilization of any given territory, mitigates the spatial conflicts and fields of concern, and delivers added value to the territory.

Ecological corridors, but most importantly, the whole networks of natural or semi-natural areas play a wide range of roles in balanced spatial development. They provide a range of ecosystem services and functions from the highly particular (protection of endangered species) to the most complex and overlapping (protecting the biodiversity of territory and facilitating various ecosystem services). They also help preserve certain species' eco tops and important migration traces. The concept of ecological networks has been developed over the past years to preserve the integrity of environmental processes. Based on this approach, intensively used areas within the landscape should be balanced by natural zones (functioning as coherent, self-regulating units). Ecological corridors must help balance all the requirements of sustainable development - environmental, social, and economical.

The majority of the ecological corridors in natural landscapes serve as migration routes for different species. In the landscapes more dominated by human impacts and activities (urbanization, agriculture, leisure time activities), elements of ecological networks are more integrated into the planning schemes and concepts, turning them sometimes into the green islands in the highly urbanized ocean. They are always

part of a bigger entity, with many binding functions [5]. Nevertheless, the goals of ecological networks are most often:

- To maintain the functioning ecosystems and to facilitate the conservation of habitats and species;
- To promote sustainable use of natural resources, reduce the impact of human activities on biodiversity, and increase the biodiversity of the given landscapes [3].

Various landscape structures are represented in ecological corridors, and their degree of connectivity might vary widely. They are either natural or occur as the result of human activities. The structure of ecological corridors might be either narrow (line) (e.g., hedgerow); wider (strip) (e.g., multi-row windbreak); or streamside vegetation (riparian). Most of them consist of the following types of landscape [5]:

- Landscape linkages, large linear protected areas between large ecosystems including undisturbed rivers;
- Conservation corridors, less protected and in many cases with recreational functions, often along rivers;
- Greenbelts protected natural lands surrounding cities to balance urban and suburban growth;
- Recreational corridors, linear open spaces with intensive recreational use;
- Scenic corridors, primarily protected for their scenic quality;
- Utilitarian corridors, canals, powerlines that have a utilitarian function but serve natural and recreational functions as well; and
- Trails, designed routes for hikers, and outdoor recreation that can function as natural corridors.

An ecological corridor, with both ecological and cultural functions, is a symbol of urban ecological or green civilization [6] and tries to find a delicate balance between the protection of various functions of natural ecosystems and economic development and requirements for effective spatial management and spatial development. In order to maintain and preserve the landscape connectivity, it is important to focus on a wider range of variables than just the conservation of ecological corridors. There is a wide range of human activities, policies, economic sectors, land-ownership relations, etc. All these have an impact on landscape connectivity.

Landscape connectivity and its maintenance have to be accepted in the spatial planning documents in the first place [3]. Spatial planning has an inevitable role here. The management of future development of any given area must carefully consider many mutually interconnected factors and act in various mutual combinations and configurations. The terms of wildlife or dispersal corridors, landscape linkages, greenways or greenbelts, and other connecting features have been proposed and drawn into conservation plans and other

planning documents. Planning delivered a certain order and pace into the landscape and set up many "crossroads" and conflicts influencing almost all sectors of human activities. Connectivity is one of the most important assets of any landscape, serving many needs and requirements of balanced spatial development. Several European strategies highlight the importance of steady development and preservation of ecological networks and connectivity. Some examples include the EU Biodiversity Strategy, The Habitat Directive 92/43/EECEU Network of Nature 2000 sites [7]. In the field of spatial planning, for decades, several guidelines have highlighted the importance of natural values and ecological corridors (European Spatial Development Perspective [8]; Territorial Agenda of the European Union [9]) in the European Union.

A very important role in the management and preservation of ecological corridors plays a country/regionally specific planning culture - a unique as well as a typical, non-casual set of approaches (based on underlying values) toward the factors playing fundamental roles in the process of spatial development within certain territory [10]. The unified system of ecological network protection recognized in all the countries of the Carpathian region is rather missing. For this reason, to foster sustainable development and the protection of the Carpathian region, the Framework Convention on the Protection and Sustainable Development of the Carpathians (Carpathian Convention) was formed [1]. However, the differences in spatial planning positions within different countries still represent an important factor influencing the development of ecological networks and implementation [11]. Additionally, the region's political visions and national policies and frameworks or legislation on ecological corridors differ. A factor influencing the effectiveness of policies and legislation related to ecological networks may be their various interpretations and uses. These are processed differently by actors on different administrative levels or structures - regional or local. According to Simeonova [11], in most cases, the institutional and legal frameworks related to nature conservation are not harmonized, impacting the ecological network's development and protection effectiveness. There are many different spatial development regulations throughout different countries that exist, among others, in the form of various informal or formal documents [1]. This variety represents one of the main problems when dealing with transnational coordination of management and protection of valuable natural areas.

Just like the policies and frameworks vary from country to country, approaches and ecological corridor identification and preservation methods differ. According to Xu et al. [12] or Simeonova [11], there are various methods used to manage or plan ecological corridors within European studies. The most used is a

GIS (Geographic Information System) analysis (82 % of the analyzed studies), frequently combined with cost-distance or graph-based analysis and spatial network analysis [12]. Other methods and approaches, such as ecological sensitivity and sustainability analysis (26 % of the analyzed studies), are used. These methods of identification and implementation of ecological corridors vary from country to country and study to study. There is a need for unification at the international level while respecting individual countries' special socio-economic, natural, political, and other conditions [11].

Spatial planning is a tool for harmonizing the interests of all stakeholders involved as all the activities meet in the space and the interests of various stakeholders meet there. Therefore, an important part of the management and planning of ecological corridors is public participation. Participatory planning gives communities certain control over decision-making. It can enhance the planning and implementation process, the quality of decisions, and the reliability of implementation [13]. It provides space for consensus-building [11], deliberation and mobilizes human capital while raising the legitimacy of decisions. Public engagement helps to improve understanding of the issue and connect data with local knowledge. It makes the whole planning process more transparent and more efficient (spatial conflicts are detected early and adopted decisions always have certain legitimacy due to various segments of actors).

It is of utmost importance that the management of ecological corridors goes beyond the narrow expert approach, thus becoming an integral part of participative planning culture and taking part in various spatial development processes. One of the important goals of spatial planning is to create and foster effective connectivity within a given area, not only in terms of accessibility but also in terms of gaining general balance and diversity of the territory - ecological corridors play one of the main roles in this process.

However, constraints that often disable public participation during the project planning, implementation, or management include insufficient funding, limited time, or weak technical expertise. The degree of public involvement of different types of stakeholders in the issue of ecological corridors management and planning differ; however, according to Xu et al. [12], it usually involves the following stakeholder types within European examples: decision-makers (e.g., representatives of governments), residents and their organizations (e.g., landowners), other participants (e.g., researchers, planners, consultants). It was also found that ecological corridors usually involve more diverse stakeholder types than other corridors (such as cultural corridors). In addition, they are often linked with diverse networks of organizations or individuals, often including the EU, the Carpathian

Convention, or other international institutions. Therefore, it can be concluded that ecological corridors represent a topic interesting to diverse groups of people. These should be involved in the participatory process of their planning and management. Balanced representation of various stakeholders/actors in spatial planning processes helps find a sustainable equilibrium in the long term, enabling correction of adopted measures, redefinition of planning consensus, and increased identification with the given territory and promotion of the values related to the territory.

Ecological corridors have a multitude of symbolic roles and social meanings within the landscape: their semiotics bears the encoded message of "connection", "agreement", and "interlinkages" - a landscape with reasonable designed ecological corridors tells us that smart people govern it, keeping the natural identity of the given area intact and preserving its *genius loci* towards the future. In that sense, the management of ecological corridors is not a mere technical or sectoral tool in terms of ecosystem maintenance and management. However, it reflects the value model of the entire society, its priorities, and its (not only spatial) vision.

3. Survey Methodology

In order to support the analyses of the main gaps in the planning processes and tools related to the ecological corridors, a questionnaire survey was carried out in cooperation with the involved countries. The 5 participating countries - The Czech Republic, Hungary, Serbia, Slovakia, and Romania are located in the largest, last remaining strongholds for the large carnivore species of the Danube-Carpathian region participants in the ConnectGREEN Project. The respondents included each country's representatives, i.e., ConnectGREEN Project partners and the associated strategic partners [14] - mainly spatial planners and nature conservationists. These were asked to distribute the questionnaire to further relevant people as well.

The questionnaire was designed following the project's objectives and the agreement between the activity leader (Hungarian University of Agriculture and Life Sciences) and the project leader (WWF Romania). It contained almost exclusively open-ended questions, including questions related to other activities of the ConnectGREEN Project. The part of the questionnaire intended for "GAP analysis on the identification of the needs for improving the planning processes and tools related to ecological corridors identification and preservation" was divided into 3 main topics: 1. Relevant policy frameworks and legislation for ecological networks; 2. Participatory planning and stakeholders' involvement; 3. Integration of spatial planning and ecological networks. This part of the questionnaire consisted of the following

questions:

3.1. Relevant Policy Frameworks and Legislation for Ecological Networks

- "Where are the main gaps in the ecological network-related policy framework?"
- "What kind of indicators are used for the identification of ecological networks?"
- "What are the main problems and challenges during the implementation?"
- "After developing ecological networks, is there any monitoring activity (what kind of indicators are used)?"

3.2. Participatory Planning and Stakeholders' Involvement

- "What types of stakeholders' involvement are applied during the planning and implementation process?"
- "Is there any compensation for farmers and landowners during the implementation?"
- "What are the main criticisms regarding ecological network development?"
- "What are the main conflicts between conservationists and other stakeholders (e.g., foresters, hunters, farmers, developers, spatial planners)?"
- "Are the stakeholders and locals aware of the importance of the ecological networks? Is there any program for promotion or information?"

3.3. Integration Spatial Planning and Ecological Networks

- "How are ecological networks integrated into spatial planning in your country? What kind of ecological network elements and at what scales appear in the spatial plans at different territorial levels (please, indicate the territorial and local levels as well)?"
- "What limitations and rules apply to land use and development possibilities according to the ecological network in spatial plans?"
- "What are the main gaps in integrating the ecological networks in other policy sectors?"
- "How deep is the integration of the ecological network-related issues in the strategic impact assessment?"

The questionnaire was sent to participants in the form of an editable document. A comparative gap analysis was conducted after the filled documents were received from representatives of all 5 participating countries. It aimed to identify crucial common problems and gaps in the planning processes and tools related to ecological corridors of the concerned countries and unique ones, specific ones to the given country. It is crucial to find the planning processes and tools gaps to find the most suitable and necessary improvement for the planning systems. Apart from

problems and gaps identification, good solutions and examples were pinpointed. The following part highlights the main findings.

4. Gaps in the Planning Processes and Tools Related to the Ecological Corridors

This part presents the main results of the analytical work of experts supported by the questionnaire survey. It provides a brief overview of the main gaps, problems, and challenges resulting from the analyses divided into three subparts:

- Relevant policy frameworks and legislation for ecological networks;
- Participatory planning and stakeholders' involvement;
- Integration of ecological networks into spatial planning.

4.1. Relevant Policy Frameworks and Legislation for Ecological Networks

This part aims to identify the main gaps in the ecological network-related policy frameworks, the indicators used during the identification of the ecological network, the main problems, and challenges during the implementation of ecological corridors, and the monitoring activities after the development of ecological networks.

4.1.1. The Main Gaps in the Ecological Network Related Policy Framework

In the context of ecological network policy frameworks, five main problem areas were identified based on the answers received from the survey participants. These include Types of regulations and consistency, Social agreement and conflicting interests; Institutional framework; Definition; and Methodology. In Fig. 1, specific problems within these areas are linked to individual countries of interest.

All the concerned countries expressed the importance of ecological networks and corridors in policy frameworks. However, unfortunately, the implementation of this idea is weak in many cases.

As fig. 1 shows, the most important gap area related to ecological corridors planning is the "Types of regulations and consistency". All the 5 countries have serious gaps in this field, mainly due to the weakness of the regulation. In Slovakia and the Czech Republic, the Territorial System of Ecological Stability (TSES) covers the country's whole territory. However, these documents are only background materials, not legally binding documents. Serbia deals with a similar issue where the lack of mandatory obligation to define and protect the ecological corridors leads to further deterioration of existing parts of natural corridors.

Types of regulations and consistency	▪ (SK) official documents dealing with ecological networks are only background not binding documents ▪ (SK) request oriented but not obligatory documents ▪ (SK) position of landscape ecological plan / environmental plan is weak in the system of spatial planning ▪ (SRB) lack of mandatory obligation to define and protect the ecological corridors ▪ (SRB) the regulation of the network management, as an intersectoral issue is not regulated ▪ (RO) irregularities, inconsistencies and legislative derogations ▪ (RO) insufficient regulations ▪ (HU) problems related to the realization of the plans, especially related to financing
Social agreement and conflicting interests	▪ (HU) the objectives of the development of ecological networks are in contrast with present developments and decision-making ▪ (HU) due to strong lobby power of some stakeholders, legal regulations cannot answer specific problems appropriately and they can launch exceptional legal rules ▪ (SRB) lack of general social agreement ▪ (SRB) different interest groups with conflicting interests
Institutional framework	▪ (RO, HU) deficient institutional framework ▪ (RO) poor implementation of legal provisions
Definition	▪ (CZ) TSES (territorial system of ecological stability) definition is not focused on ecological connectivity for animal species, it is not usable for large carnivores ▪ (SK) weak and old definition of ecological networks
Methodology	▪ (CZ) outdated methodology ▪ (CZ) the new methodology does not contain desirable changes and improvement, and only copies the old one

SK = Slovakia, SRB = Serbia, RO = Romania, HU = Hungary, CZ = The Czech Republic

Fig. 1 Specific problems within concerned countries related to the ecological network policy framework

Due to the lack of legal obligations on corridor issues in international conventions, there are difficulties in network creation at the national level. The National Strategy highlights the irregularities, inconsistencies, and legislative degradations related to spatial/urban planning and natural and cultural heritage protection in Romania. In the case of Hungary, the problem is related mainly to financial issues, while in the Czech Republic, the problem is related to flawed methodology.

Gaps related to the "Social agreement and conflicting interests" and "Institutional framework" were identified in more than one country. In Hungary and Serbia, the different interest groups with conflicting interests cause serious problems when implementing the regulations and programs. A serious problem in Hungary is the strong lobby power of some stakeholder groups, which often causes the weak efficiency of the ecological network-related policies. In Romania and Hungary, deficient institutional

frameworks were detected as well.

In addition to the mentioned gap areas, the outdated *methodology* and the weak and old *definition* of ecological networks and corridors cause problems in Slovakia and the Czech Republic. For example, in the Czech Republic, the methodology of TSES definition is not focused on ecological connectivity for animal species. Therefore it is not usable for large carnivores.

4.1.2. Indicators Used for Identification of Ecological Networks

All the analyzed countries within the Danube-Carpathian region use indicators for ecological networks and corridor identification. In most cases, they are based on the Natura 2000 and the Pan-European Ecological Network methodologies. However, differences were identified in the used indicators and their importance.

These differences among the countries are mainly due to the available database and the legislation background. That makes the elaboration of common networks and related communication more difficult, and thus these differences represent a significant problem. However, the indicators, methodology, and plans/maps could be updated soon in several cases (e.g., Hungary). Furthermore, due to the large carnivore species' range significant increase in Europe, updating the ecological networks and corridors map and its reinforcement into the law is crucial. That would help to keep the landscape suitable for wildlife and their movements.

4.1.3. The Main Problems and Challenges during the Implementation of Ecological Corridors

The questionnaire survey identified six main challenges related to the implementation of ecological corridors. These challenges are technical, communicational, methodical, interest, skills, and financial.

The main problems during the implementation of ecological corridors within the concerned countries are related to the technical, communicational, methodological, and interest issues, as Fig. 2 shows. In the Czech Republic, Hungary and Serbia, the *technical aspect* means mainly the lack of data or their accessibility. For example, a lack of data on populations, habitat maps, and insights into sectoral plans can be observed in Serbia.

One of the main challenges in the Czech Republic is the missing information system. Meanwhile, in Hungary, what causes difficulties during the implementation process is the (in)accessibility of the existing database.

	CZ	HU	SRB	SK	RO
Technical (e.g. database)	✓	✓	✓		
Communicational	✓	✓			✓
Methodical	✓		✓	✓	
Interest		✓		✓	✓
Skills	✓		✓		
Financial		✓	✓		

CZ = The Czech Republic, HU = Hungary, SRB = Serbia, SK = Slovakia, RO = Romania

Fig. 2 Types of the main challenges during the implementation of ecological corridors within concerned countries

A basic challenge in the Czech Republic, Hungary, and Romania is insufficient *communication*. That means mainly the lack of collaboration between the authorities and the landowners (or other stakeholders) in all three cases.

Challenges related to *methodical* issues cause problems mainly in the Czech Republic, Serbia, and Slovakia. That is related to outdated methods and measures in the first two countries.

The *conflicting interests* represent a challenge during the implementation of ecological corridors in Hungary, Slovakia, and Romania. As part of the "skills" challenges, the lack of professional staff causes difficulties, especially in the Czech Republic and Serbia. At the same time, insufficient *financial* support was identified in Hungary and Serbia, as fig. 2 shows.

4.1.4. The Monitoring Activities after the Development of Ecological Networks and Used Indicators

Regarding the monitoring activities after the development of ecological networks, gaps and weaknesses were identified in the analyzed countries. As fig. 3 shows, only two countries (the Czech Republic and Romania) have *direct monitoring activities*. The other three countries (Hungary, Serbia, and Slovakia) have *indirect (optional) monitoring activities*.

However, these are not widespread in practice - they are usually related to certain projects or research. It would be beneficial to implement these good examples in general practice. The used *indicators* in the analyzed countries differ as well. Nevertheless, the methods, as well as the indicators, should be harmonized.

Direct monitoring activity

- **(CZ)** On a regular basis, authorities responsible for the conservation of the natural environment conduct assessments of ecological stability system in terms of their stabilization potential.
 - **Types of indicators used:** Detailed delineation of the boundaries of the systems, the level of biological diversity, an assessment of the vegetation makeup in the system and the ability of the ecosystem to resist the effects of pollution, erosion or other physical or chemical environmental stress factors.
- **(RO)** The management of protected natural areas shall be assessed at least once a year on the basis of the monitoring and on-site inspections by the competent environmental authorities.
 - **Types of indicators used:** Biodiversity monitoring - monitors the tourism to determine its impact on the flora and fauna of the site and to establish the protective measures required.

Indirect (optional) monitoring activity

- **(HU)** Monitoring activities are existing for the Natura 2000 areas, however these are usually optional (there is not enough financial and human resource existing). From 1997 the National Biodiversity Monitoring System has developed methods for the monitoring, however these are not generally widespread.
- **(SRB)** Some observations and surveillance are practised, rather than a monitoring on some species and habitats, but it is not specifically in connection with the ecological network.
- **(SK)** The state nature conservancy system provides the monitoring of the networks as its own initiative. Some monitoring activities used to be prescribed as the output form the EIA process.

CZ = The Czech Republic, RO = Romania, HU = Hungary, SRB = Serbia, SK = Slovakia

Fig. 3 Types of monitoring activities and indicators after the development of ecological networks and corridors

4.2. Relevant Policy Frameworks and Legislation for Ecological Networks

Public participation is an important part of ecological corridor management and planning. In this part, the following issues are analyzed within the concerned countries: main gaps in the stakeholders' involvement; main gaps in the compensation system; main conflicts between the different stakeholders; and the awareness of the importance of the ecological networks.

4.2.1. The Main Problems and Challenges during the Implementation of Ecological Corridors

In all five analyzed countries, the importance of stakeholders' involvement is very similar. In all cases, legal rules define the stakeholders and public bodies (e.g., ministries, public institutions, and public enterprises). Their obligations are regulated - their prime task is to provide information and data and participate in consultations and discussions. In most of the analyzed countries, the scope of stakeholders is broadened by the Strategic environmental assessment (SEA) directive (e.g., in Slovakia and Hungary). All subjects interested in the issue have formal access to the planning process.

Based on the questionnaire survey, all the analyzed

countries guarantee the right to be consulted in the decision-making process regarding environmental policy and legislation development, issuance of regulatory acts in this field, and elaboration of plans and programs. However, public participation is insufficient due to the lack of human and financial capacities and the lack of interest (e.g., Slovakia). Participation often has a form of informing rather than a real discussion and cooperation.

4.2.2. The Main Problems and Challenges during the Implementation of Ecological Corridors

Based on the type of compensation, it is possible to cluster the concerned countries into 2 groups: the ones where the compensation is regulated by law; and the ones where the compensation exists but needs further clarification (Fig. 4).

	CZ	HU	SRB	SK	RO
Compensation regulated by law	✓	✓		✓	✓
Compensation, but needs further clarification			✓		

CZ = The Czech Republic, HU = Hungary, SRB = Serbia, SK = Slovakia, RO = Romania

Fig. 4 Types of compensation in the analyzed countries

As Fig. 4 shows, it is possible to identify significant gaps related to the compensation in the case of Serbia. A certain type of compensation exists; however, the same cases and ways of compensation are not defined. In the remaining four countries, the compensation is regulated by law; however, in some cases, the compensation mainly relates to the Natura 2000 areas (e.g., in Hungary or Slovakia).

4.2.3. The Main Criticisms Regarding the Ecological Network Development

The most common criticism, which occurred in all the analyzed countries, is the *weak implementation*. The theoretical and legal framework and the identification of ecological networks are more or less present in all cases. However, the implementation of the plans or programs is quite weak. Other criticisms frequently mentioned in the questionnaire survey are lack of financial support, lack of professional staff; lack of good communication and real public participation; and difficult access to data.

4.2.4. The Main Conflicts between Conservationists and Other Stakeholders (e.g., Foresters, Hunters, Farmers, Developers, Spatial Planners)

Conflicts are present in all the countries involved in the questionnaire survey. As indicated within the

answers, the main reason for the conflicts was primarily the *lack of proper communication or miscommunication* (e.g., in Hungary or Serbia). Problems also occur due to the *lack of an efficient compensation system* - to compensate for the limitations of land use (e.g., in Slovakia). Another problem seems to be the *non-recognition of nature conservation as a sector that is protecting natural resources* (e.g., in Serbia).

4.2.5. Stakeholders' and Locals' Awareness of the Importance of the Ecological Networks and Programs Supporting Its Development

Most of the locals and other stakeholders are not aware of the ecological network's importance in any of the concerned countries (except Romania). It is considered a major deficiency in most countries, and there is no information campaign in any of them. Therefore, only some occasional local initiatives can be considered certain communication tools for informing the broader public about the importance of ecological networks (e.g., in Serbia).

4.3. Integration of Ecological Networks into Spatial Planning

In this part, the following areas were analyzed based on desk research, experts' assessment, and answers obtained in the questionnaire survey: the way and depths of ecological networks' integration into the system of spatial planning; the limitations related to ecological networks in spatial plans; the gaps in the integration of the ecological networks in other policy sectors; and the integration of the ecological network-related issues in the SEA (Strategic Environmental Assessment).

4.3.1. Integration of Ecological Networks into Spatial Planning, Ecological Network Elements, and Scales of Their Appearance in the Spatial Plans in Different Territorial Levels

Ecological networks in all the concerned countries are integrated into the spatial planning system. They are, however, integrated on different levels (territorial, maps/GIS layers, local), as Fig. 5 shows.

Spatial maps or GIS layers addressing ecological networks are present in the spatial plans of all the concerned countries except Serbia. Although the ecological networks are formally stated in spatial plans in Serbia, they are usually mentioned in generalized formulations. These are about the necessity of their identification, valorization, and protection, but ecological networks are not spatially defined in maps. However, good examples can be found in Serbia, where spatial definition and protection measures are identified in the Regional Spatial Plan for Vojvodina Province.

Integration of ecological networks into spatial planning on...			
	territorial level	maps/GIS layers	local level
CZ	✓	✓	✓
HU	✓	✓	✓
SRB	✓		✓
SK	✓	✓	✓
RO	✓	✓	✓

CZ = The Czech Republic, HU = Hungary, SRB = Serbia, SK = Slovakia, RO = Romania

Fig. 5 Types of integration of ecological networks into spatial planning

On a *local level*, gaps were found in several countries. In Serbia, the problem is similar to the territorial level (although ecological networks are treated formally, they are mentioned in generalized formulations). In the Czech Republic, the information about the area, lengths, and coverage of ecological networks is rarely digital and available only on the part of the territory. In Hungary, the main problem is the inconsistency of spatial plans on different levels from the perspective of ecological networks. In practice, this means that, for example, the designation of ecological networks on a local level is based on estate records, which is hardly comparable with the national ecological network.

In all the analyzed countries, conservation areas significant on an international and national level are addressed at all spatial levels. However, the above-presented problems exist in all types of conservation areas.

4.3.2. Limitations or Rules Applied for the Land Use and Development Regarding the Development and Protection of Ecological Networks in Spatial Development Plans

According to the ecologic network in spatial plans, there are certain limitations to land use and development possibilities in all the analyzed countries. The only exception is Serbia, where ecological networks are only formally mentioned in the spatial plans and other planning documents. Limitations are *usually related to the maintenance of zones/areas to preserve their existing conditions*. The limitations or rules are very similar in all the analyzed countries. That is mainly related to forbidding disturbing activities and activities that affect ecological stability (e.g., tourism activities, certain types of transport or forestry, hunting or fishing activities, grassland management, etc.). Therefore, it is usually possible to limit the changes in all the concerned countries but not prescribe them.

4.3.3. *Limitations or Rules Applied for the Land Use and Development Regarding the Development and Protection of Ecological Networks in Spatial Development Plans*

Within this question, the analyzed countries' deficiencies and problems differ. However, most of the gaps are related to:

- Insufficient communication between individual sectors;
- The barriers within the regional development and spatial planning sectors (e.g., the Czech Republic, Hungary, and Romania); and
- Barriers within the public administrations (e.g., the Czech Republic, Hungary, and Slovakia).

In Serbia, the main problem represents the rules and recommendations related to the ecological networks. These are not adapted to other strategic or planning documents. The lack of appropriate and exact measures for identifying, evaluating, and protecting ecological corridors causes problems in Slovakia and Serbia. The Landscape Plan in Romania (on the territorial and local level), as a good example, will operate as an integrating tool of cultural and natural heritage protection policies.

4.3.4. *Limitations or Rules Applied for the Land Use and Development in Regard to the Development and Protection of Ecological Networks in Spatial Development Plans*

In the analyzed countries of the Czech Republic, Hungary, Slovakia, and Romania, the ecological network-related issues are integrated into the SEA (Strategic Environmental Assessment). The one exception is Serbia, where ecological network-related issues are not mentioned in the existing legislative framework. However, the new draft of the Law of SEA has proposed an obligation to start SEA for plans and programs for which it is determined that they can have a significant negative impact on the ecological network (according to a spatial regulation in the area of nature protection).

5. Discussion

The paper contributes to the research topic by providing valuable data about the state of ecological corridors identification, management, and preservation within the Danube-Carpathian ecoregion. That was achieved by surveying five concerned countries from the ecoregion, which provided information about the mentioned above. There is much knowledge gathered about ecological corridors or ecological networks in previous studies. Researchers provide recommendations and best practice examples. However, knowledge about the respective region is needed to implement the recommendations. Data related to the state of ecological corridors identification, management, and preservation within the Danube-Carpathian region were not procured in

previous studies until this point. Even though the research participants did not include the general public (e.g., landowners and farmers) or representatives of the public bodies (e.g., ministries and public agencies), the gathered information provided reliable data for formulating conclusions. These data serve as information for later recommendations and strategies to minimize fragmentation within the ecoregion and maintain crucial biodiversity hotspots and valuable ecosystems on the continent. Based on the gathered data, improvements in the following areas are recommended for the ecoregion:

- Communication and information between various sectors as well as towards the public;
- Data collection and their accessibility (public databases etc.);
- Harmonization of methods as well as the indicators within the region;
- Inclusion of ecological networks and ecological corridors in policy frameworks;
- Position of the regulations in the spatial planning;
- Update of ecological networks and corridors map and its reinforcement into the law;
- Implementation of monitoring activities is a good example of developing ecological corridors from certain projects or research into general practice.

6. Conclusion and Recommendations

Habitat fragmentation represents a significant problem in the context of sustainable spatial development. This issue is relevant to the Danube-Carpathian region too, which is one of the most preserved natural habitats for wildlife species in Europe. ConnectGREEN project aims to improve the ecological connectivity between natural habitats of this area to cope with the issue. The novelty of the project and this paper subsists through research analyzing the questionnaire survey answers of 5 participating countries of the Danube-Carpathian region. The questionnaire survey method allowed the collection of a vast amount of information from multiple stakeholders from several countries in the Carpathian Region. The questionnaire structure enabled authors to collect, compare, and analyze the data, which were then turned into policy recommendations formulated below. We have identified the main gaps in ecological corridor identification, management, and preservation. Identification of a problem is the first step to tackling it. The project framework, which also includes the Carpathian Convention, provides a solid background for reflecting on these international – European – level issues. The main problems seem to be rooted in insufficient communication, availability of data, weakness of the regulations, and inconsistencies in methodologies related to ecological corridors within

the region. The results can be summarised in three main points:

(1) Even though the importance of ecological networks and corridors in *policy frameworks* is expressed in all the analyzed countries, the policy frameworks lack consistency and enforcement within the region. Their position in the planning system is often insufficient. The definition of ecological networks and the methodology for identifying and managing them are non-existent or outdated. Another identified problem is the social agreement and conflicting interests throughout the topic, which cause problems during the implementation phase. Differences within the analyzed countries were detected in the used indicators for ecological corridors identification, where the reason is mainly the database availability and the legislation background. It makes the elaboration of common networks and related communication more difficult. Communication and collaboration represent a challenge in the process of implementation of ecological corridors as well. Other identified challenges in this process can be described as technical, methodical, skills, and financial issues. Again, the technical challenges are related mainly to the lack of available data. Regarding the monitoring activities after the development of ecological networks, direct monitoring activities are rare. More common are indirect (optional) monitoring activities, but these are usually implemented in certain projects or research, not in practice.

(2) Gaps in *participatory planning* and stakeholders' involvement appear mainly due to a lack of human and financial capacities and motivation, insufficient communication, and difficult access to data. Within the given region, participation often has a form of informing rather than a real discussion and cooperation. At the same time, nature conservation is not recognized as a sector protecting natural resources. The lack of proper communication also appears in the identified reasons for conflicts between conservationists and other stakeholders. Most locals and other stakeholders are not aware of the ecological network's importance in most analyzed countries. Regarding the compensation practices to farmers and landowners during the implementation phase, it is regulated by law in most cases, however, in some cases, it mainly only relates to the Natura 2000 areas, and an efficient compensation system is lacking.

(3) The *integration of ecological networks into spatial planning* happens on different levels (territorial, maps/GIS layers, local) within the region. Limitations or rules to land use and development possibilities according to the ecologic network in spatial plans are usually related to the maintenance of zones/areas to preserve their existing conditions. Therefore, it is usually possible to limit the changes in all the concerned countries but not to prescribe them. Gaps in

integrating the ecological networks in other policy sectors differ within the analyzed countries. However, most of the gaps are related to insufficient communication between individual sectors, barriers within the regional development and spatial planning sectors, and barriers within the public administrations. However, in most cases, the ecological network-related issues are integrated into the SEA (Strategic Environmental Assessment).

The research limitations include the survey not covering all Carpathian countries (excluding Poland and Ukraine) and the questionnaire not being followed by in-depth interviews with selected stakeholders. This step was omitted within the ConnectGREEN Project as project partners provided more in-depth information, but external stakeholders did not justify this.

As the main gaps in ecological corridor identification, management, and preservation throughout the Danube-Carpathian region were identified, the research perspectives should further shift the focus to implementing the proposed change and improvements in practice. Furthermore, it would be useful to explore the topic of sustainable infrastructure development concerning the maintenance and preservation of ecological networks and biodiversity (which is already ongoing in the H2020 BISON Project [15]). That is especially important in the new climatic conditions and the intensive rise of new transport infrastructure development in Eastern Europe. At the same time, the issue of ecosystem fragmentation builds up. Nevertheless, the Danube-Carpathian region will face various challenges in the future related to biodiversity, connectivity, and nature protection. It needs to be thoroughly prepared to sustain its position as one of the most preserved natural habitats for wildlife species in Europe.

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