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Protecting or Destroying? Romania's Biodiversity in the Face of Modern Challenges

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ABSTRACT

This article explores the current state of biodiversity in Romania, with a focus on agricultural biodiversity and the pressures exerted by industrialization, modernization, and globalization. It examines the spatial, structural, and biological dimensions of biodiversity to provide an integrated perspective on ecosystem complexity. Using species observation data from the GBIF platform and national statistics on agricultural land use, a simple regression analysis is conducted to investigate the relationship between agricultural surface area and observed biological diversity. The findings highlight the importance os sustainable policies and choices that can shift the balance toward biodiversity protection in the face of increasing socio-economic and environmental pressures.

1. Introduction

Romania is one of the richest European countries in terms of biodiversity – from the aquaric ecosystems of the Danube Delta to the ancient forests of the Carpathian Mountains and the traditional agricultural diversisity. However, this unique natural heritage is increasingly vulnerable to current pressures: intensive agriculture, massive deforestation, uncontrolled urban expansion, and the accelerated effects of climate change. In this article, I will focus on the main dimensions of biodiversity – spatial, structural, and biological – and analyze how industrialization and globalization processes affect the natural balance. Additionally, I will investigate a scientifically and practically relevant relationship through a simple regression: how habitat fragmentation or land-use changes influence the diversity of local species. Through this approach, I aim to answer the essential question: Are we protecting or destroying this natural treasure?

2. Literature review

Romania stands out for its exceptionally rich biodiversity, particularly in areas such as the Carpathian Mountains and the Danube Delta, where complex ecosystems support an impressive variety of species. Official documents from the Ministry of Environment, Waters, and Forests provide relevant data on the Natura 2000 metwork of sites and forest fund management, serving as a solid foundation for understanding the current state of national biodiversity (Ministry of Environment, Waters, and Forests, 2023). According to official data, the country has 606 Natura 2000 sites, representing a crucial network for biodiversity conservation at the European level. These findings are essential for understanding the current state of national biodiversity.

An important focus of the scientific literature is agricultural biodiversity, emphasizing the essential role of pollinators in maintaining ecosystem balance and food security. The BeeActive project, implemented by WWF Romania, analyzed the impact of agricultural practices – both intensive and traditional – on insect diversity in the Transylvanian Hills, preliminary results highlight significant differences in insect diversity based on land-use practices (WWF Romania, 2022). These findings are complemented by studies demonstrating the importance of species such as honeybees (Apis mellifera), bumblebees (Bombus spp.), wasps, and various fly species for pollination and agricultural production stability (Romanian Ornithological Society, 2023).

In agricultural areas, the relevance of biodiversity is supported by projects such as BeeActive, as well as by recent field studies: for example, Stoenescu, Stan, and Stănică (2025) documented, in a jujube orchard in Oltenia, the presence of 57 insect species with high diversity indices, indicating that traditional agroecosystems can sustain a rich etomological community (Stoenescu, Stan & Stănică, 2025). Similarly, Cosmulescu, Stamin, Răduțoiu, and Gheorghiu (2025) studied spontaneous vegetation in grassy strips between rows of fruit trees in plum, cherry, and apple orchards in Dolj County, finding that these strips support considerable wild-

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herbaceous diversity and a complex ecological structure, particularly in apple orchards, suggesting the role of grassy strips as an essential element for structural biodiversity in agriculture (Cosmulescu, Stamin, Răduțoiu & Gheorghiu, 2025).

Agricultural genetic diversity is in decline, and local cattle breeds are illustrative of this trend. Paraschivescu (2023) documents a drastic reduction in the numbers of indigenous cattle breeds from 1990 to the present, highlighting both numeric loss and loss of ecological value, especially in areas where intensive agriculture does not yet dominate the rural landscape (Paraschivescu, 2023). This study aligns closely with the theme of this article concerning biological and genetic biodiversity, suggesting the importance of using official data on native breeds in the analysis I will undertake.

The need for genetic protection of indigenous breeds is also confirmed by studies such as Study on the Evolution of Genetic Resources of Domestic Animals in Romania (Sandu, Străteanu & Udrea, 2024), which show significant declines in the populations of certain traditional breeds, as well as initiatives to establish genetic quality programs (Sandu, Străteanu & Udrea, 2024). This strengthens the argument that (genetic) biodiversity is essential for the resilience of agricultural systems, which is a central theme of the present article.

Anthropic pressures and agricultural policies play a decisive role in biodiversity. The European Court of Auditors' Special Report "Biodiversity on farmland: CAP contribution nas not halted the decline" shows that the Common Agricultural Policy has not succeeded in reversing the decline of biodiversity, largely due to inefficient or insufficiently evaluated measures (European Court of Auditors, 2020). At the same time, WWF has highlighted that a significant proportion – up to 60% - of European agricultural subsidies support farming practices harmful to the environment, thereby compounding negative trends for biodiversity (WWF Romania, 2024).

In addition to these direct pressures, climate change represents a major risk factor. Drought and aridification, especially observed in Dobrogea and southern Moldova, are causing significant losses in crops such as wheat, maize, and sunflower (Thought, 2025). Climate projections for 2050 indicate yield declines of over 10-13% for maize under many scenarios, with worse losses in drought years, which amplifies the vulnerability of agriculture and, consequently, the biodiversity that depends on it (Thought, 2025; WWF-Romania modelling).

The effects of intensive agriculture on biodiversity have also been examined from the perspective of its impact on common farmland birds. A recent European study, which includes Romania, suggests that their decline cannot be explained solely by agricultural intensification, but rather by a combination of factors that alter habitat structure and resource availability (Rigal et al., 2023). Meanwhile, the genetic conservation of indigenous animal breeds remains an essential pillar of agricultural biodiversity. The ADER-824 project, implemented by the Agricultural Research-Development Station Turda, aims to conserve the traditional pig breeds Bazna and Mangaliţa through developing sustainable genetic lines, thus contributing to preserving the national ganetic heritage (Turda Agricultural Research and Development Station, 2023).

At the international level, a large meta-analysis of studies demonstrates that conservation interventions – such as habitat restoration and the control of invasive species – can have significant positive effects and may help stop or even reverse biodiversity decline.

On the other hand, a recent bibliometric analysis by Todirică, Ciornei, Petcu, Simion, and Joiţa-Păcureanu (2024) confirms the evolution of the research field in Romania: shifting from interests focused on natural ecosystems toward emerging values such as sustainability, species richness, and conservation management. In addition, A Decade of Bibliometric Analysis of Biodiversity (Simion, Ciornei, Todirică, Petcu & Joiţa-Păcureanu, 2023) provides precedent for publication trends and themes of interest, allowing this study to be placed clearly within an academic continuity.

To supplement the analysis based on statistical and observational data, I considered it necessary to carry out an additional review of the specialized literature. In this regard, I performed a systematic search in the SCOPUS database using the keywords: "Romania's biodiversity" and "agricultural biodiversity in Romania". The results obtained provide a meaningful picture of the academic concerns in this field, highlighting the main research directions, analytical trends, and challenges identified at both national and international levels.

In this section, a co-occurrence analysis using VOSviewer was employed to highlight the most frequently associated keywords. This approach enables the identification of the main research directions, emerging themes, and potential perspectives for future studies, The interpretation of these bibliometric data is presented below.

Table 1. Top 10 keywords

Keyword	Occurrences	Total link strength
Biodiversity	518	4402
Romania	433	3983
Forestry	70	858
Ecosystems	80	826
Europe	61	743

Keyword	Occurrences	Total link strength
Conservation	83	733
Animals	50	705
Climate change	60	700
Land use	48	596
Species diversity	46	585

Source: Created by authors in VOSviewer software

The keyword co-occurrence analysis, applied with a minimum threshold of five occurrences per term, revealed that only 407 out of the initial 6,259 words met this criterion. These terms were then grouped into seven thematic clusters. High-frequency but thematically insignificant words – such as "article", "environmental protection", "non-human", "Carpathians", "vegetation" – were excluded for clarity. Table 1 presents the top 10 keywords, ranked by total link strength and number of occurrences.

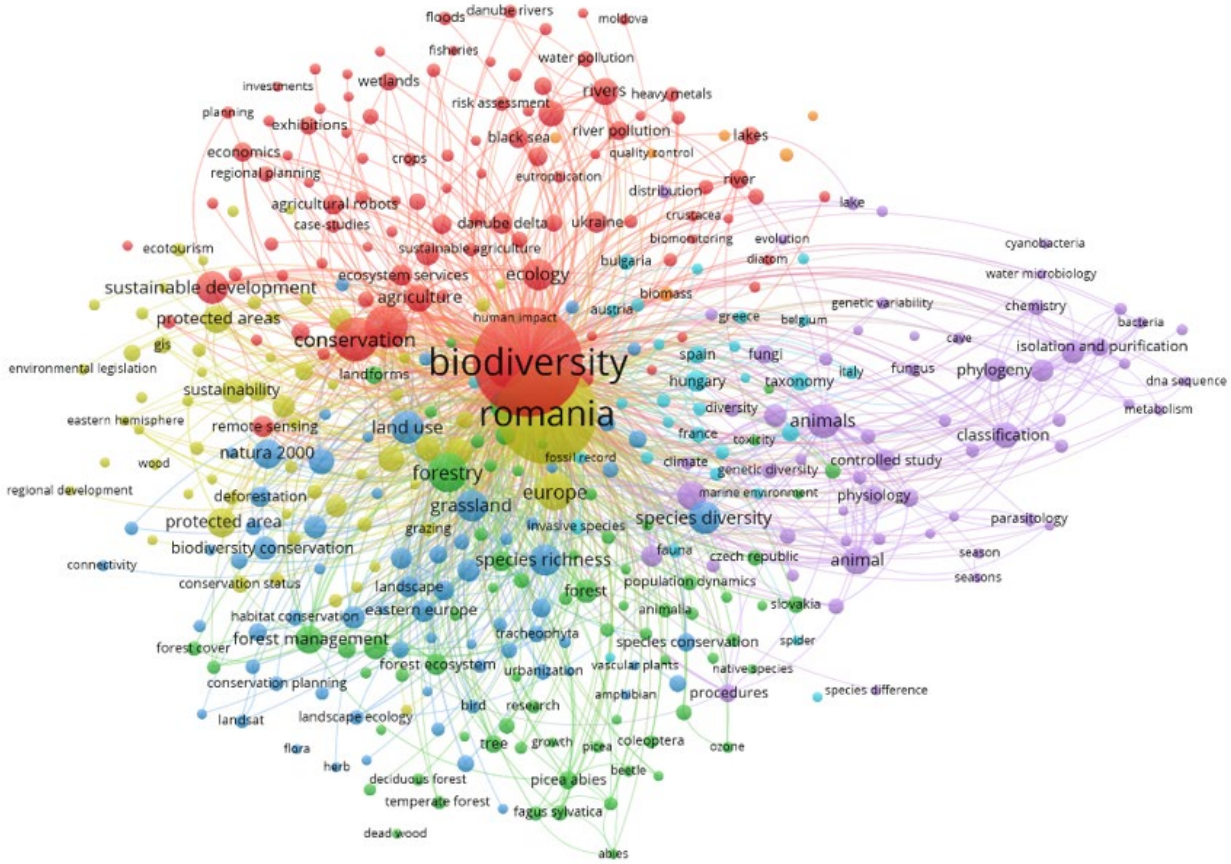

Figure 1. Cluster map

Source: Processed in VOSviewer

The first group, labeled "biodiversity", records 518 occurrences and 4,129 links, characterized by high density and centrality. This term appears both in Cluster 1, in associations such as biodiversity, biodiversity indexes, biodiversity protection, and in Cluster 3 through concepts such as biodiversity conservation or farmland biodiversity, reflecting the fact that biodiversity has long been recognized as a fundamental resource that requires protection.

The second thematic group, "Romania", has a total of 433 occurrences and 3,721 links. Works included in this group focus on characterizing geographic spaces – Romania as a whole, the Carpathians, Bucharest – and appear in Clusters 1, 3, and 4. For example, in Cluster 4 there are two articles emphasizing the national context, indicating a strong interest in geography, localization, and research specificity.

The term "conservation" constitutes the third group, with 83 occurrences and 682 links. This group comprises works that focus on the conservation of water, soil, habitats, and species, as well as the protection of natural resources, and it is predominantly present in Clusters 1, 3, 4, and 5.

The "ecosystems" group (80 occurrences, 791 links) encompasses studies referring to aquatic, terrestrial ecosystems and the general concept of ecosystem, predominantly located in Cluster 1.

"Forestry" (70 occurrences, 817 links) is present mainly in Cluster 2, reflecting concerns related to forestry, forests, and the management of forest resources.

The "Europe" group (61 occurrences, 708 links) includes articles focused on the European context – Central Europe, Eastern Europe, the European Union – and appears in Clusters 3, 4, and 6.

In the seventh group, "animals" (50 occurrences, 625 links), the works focus on animal – related topics, predominantly in Cluster 5, suggesting a narrower, but stable, interest in animal diversity within Romanian biodiversity literature.

Based on the comparisons made, it appears that agricultural biodiversity is increasingly present in the literature. However, there are still gaps: longitudinal studies are scarce, the indicators used in assessments are often generalized, and the full integration of genetic, observational, and socio-economic data remains insufficiently explored. This article aims to contribute precisely to this area – providing a combined analysis that reflects both spatial and structural changes as well as biological aspects of biodiversity within the context of modern agriculture.

The co-occurrence analysis in VOSviewer highlights themes such as "Romania", "biodiversity", "conservation", and "forestry" as dominant in terms of frequency and centrality, providing insight into scientific interest. To contextualize these results from a socio-economic and structural perspective, recent data shows that Romania had approximately 2.859 million agricultural holdings in 2023, managing about 12.55 million hectares of land, with an average farm size of approximately 4.39 hectares per farm. Unincorporated farms, which constitute the majority numerically, operate on much smaller areas (around 2.74 hectares), while incorporated farms cover nearly 190.51 hectares on average. Although very small farms (under 1 hectare) account for over half of the total number of farms, they utilize a significantly smaller portion of the national agricultural area. These data suggest a fragmented agricultural structure, which may influence how biodiversity is effectively present and studied: areas with small farms may preserve traditional habitats and local species but have limited resources for data collection, whereas large farms may have a greater capacity to implement intensive agricultural practices that affect biodiversity (Agroberichten Buitenland, 2025; Decline in Agricultural Holdings and Utilized Land in Romania, 2025).

Therefore, this article contributes to understanding the evolution of biodiversity research in Romania and identifying future directions for its protection and conservation.

3. Methodology

The methodology of this study combines bibliometric analysis with recent socio-economic data to contextualize the trends identified through VOSviewer. The bibliometric analysis was conducted on publications from Scopus identified using the keywords "Romania's biodiversity" and "agricultural biodiversity in Romania), applying a minimum threshold of five occurrences for each term. These terms were then grouped into thematic clusters.

Socio-economic data were sourced from the National Institute of Statistics and official reports. In 2023, Romania had approximately 2.859 million agricultural holdings utilizing about 12.55 million hectares of land, with an average farm size of approximately 4.39 hectares. Unincorporated farms had an average size of 2.74 hectares, while incorporated farms averaged 190.51 hectares (INS, 2023; Agroberichten Buitenland, 2025). These figures are used for descriptive analyses exploring farm structure and implications for agricultural biodiversity.

4. Results and discussion

Biodiversity, or biological diversity, refers to the variety of life on Earth, including species diversity, genetic diversity within species, and ecosystem diversity. This definition is internationally recognised and is essential for understanding the complexity and interdependence of life on the planet.

Importance of biodiversity in the Romanian context

Romania stands out for its exceptional biodiversity in Europe, thanks to its geographic position, varied terrain, and diverse climate. This natural richness has multiple implications:

- **Ecosystem stability:** Species diversity contributes to the resilience of ecosystems, allowing them to adapt to and withstand disturbances such as climate change or human activities.
- **Economy:** Natural resources like forests, waters, and fertile soils support vital economic sectors such as agriculture, forestry, and fishing.
- **Tourism:** Diverse natural landscapes and unique species attract tourists, promoting ecotourism and contributing to the economic development of rural areas.
- **Culture and identity:** Local traditions and customs are often tied to elements of biodiversity, reflecting a deep relationship between communities and their environment.

Conserving biodiversity in Romania is not just an ecological responsibility, but also a necessity for maintaining the country's economic and social balance.

Agricultural biodiversity in Romania

Starting from the question "What does agricultural biodiversity mean?", we can say that agricultural biodiversity refers to the totality of plant, animal, insect, microorganism, and other forms of life that contribute directly or indirectly to agriculture. This includes both cultivated or domesticated species, as well as wild

species that support agricultural ecosystems (e.g. pollinators, natural predators, spontaneous plants, etc., see Table 2). It also encompasses all life forms that play a role in agricultural systems: crop plants, domestic animals, associated wild species (insects, birds, microorganisms, etc.), and even weeds or pests (as part of ecological balance).

Table 2. Species characteristic of the agricultural area in Romania

Pollinators and beneficial insects (natural pollinators)	The European bee (Apis mellifera) – crucial for crop pollination.
	Bumblebees (Bombus spp.) – efficient in pollinating legumes.
	May beetle (Melolontha melolontha) – sometimes harmful, but part of the food chain.
	Colorado potato beetle (Leptinotarsa decemlineata) – although harmful, it is relevant for the study of the diversity of associated fauna.
Birds associated with farmland	The crow of sowing (Corvus frugilegus) – it eats insects and larvae.
	Goldfinch (Carduelis carduelis) – feeder on spontaneous seeds.
	The field lark (Alauda arvensis) – indicator species for the condition of meadows and crops.
	Jay (Garrulus glandarius) – contributes to the natural regeneration of vegetation.
Ecologically useful wild plants / "weeds" (spontaneous plants)	The red poppy (Papaver rhoeas)
	The blue (Centaurea cyanus)
	Chamomile (Matricaria chamomilla)
	Wild clover (Trifolium)
These support pollinating insects and granivorous birds.	
Auxiliary insects (natural predators, beneficial insects)	The ladybug (Coccinella septempunctata) – aphid consumers.
	Parasitic wasps (Ichneumonidae) – controls caterpillar populations.
	Solar spiders (Lycosidae) – natural predators in cereal crops.
Worms and beneficial soil microorganisms (soil fauna)	Earthworms (Lumbricus terrestris) – soil aeration and humus formation.
	Mycorrhizae (symbiotic fungi) – help plants absorb nutrients.
	Millipede (Myriapoda)
	Fungous (Fungi)
	Bacteria (Bacteria)
Traditional domestic animals (part of agro-biodiversity)	Romanian breed oxen (e.g.: Bălțata Românească)
	The Turkish Sheep
	Mangalitsa pig – an ancient breed with valuable genetic resistance.
	Transylvanian Neck-Golaș Chicken – a rustic native breed.

Source: Created by the author based on analysis

Agricultural biodiversity is not just a natural resource, but also an essential factor for the stability and sustainability of production systems. Species diversity among plants, animals, and microorganisms helps maintain the ecological balance of cultivated lands, supporting their resilience in the face of climate change and socio-economic pressures. The main roles that biodiversity performs in agriculture are summarized in Table 3.

Table 3. The role of agricultural biodiversity

The role of agricultural biodiversity	Natural protection against pests;
	Increasing soil fertility;
	Ensuring pollination;
	Stability of agricultural production under varying climatic conditions;
	Preservation of local genetic heritage.

Source: Created by the author based on analysis

Agricultural biodiversity is an essential, often neglected component, but extremely valuable for soil health, pollination, biological pest control, and ecosystem resilience. To understand in depth the complexity and vulnerabilities of biodiversity in Romania – including in agricultural zones – it is essential to analyze its fundamental dimensions (spatial, structural, and biological, Table 4), alongside the effects of industrialization and globalization processes, as well as the influence of natural, economic, and social risk factors.

Table 4. Biodiversity dimension: spatial, structural and biological

Size type	What does it mean?	Example from Romania
Spatial	Distribution of species in the territory (mountainous, plain, humid, agricultural areas).	High diversity in the Carpathians and Danube Delta vs. Poor in industrialized agricultural areas.
Structural	Ecosystem organization: relationships between species, food chains, habitats.	Secular forests with multiple ecological layers (e.g. Vlăsia Forests).
Biological	Genetic and specific variety: wild, cultivated and domesticated species.	Native Romanian wheat, Mangaliţa pig, endemic species (e.g.: hay viper).

Source: Created by the author based on analysis

Disturbing any of these levels leads to consequences for the entire ecological system, which explains why uncontrolled modernisation processes can lead to the diminishment of biodiversity in multiple dimensions. While rapid development brings significant economic benefits, it is accompanied by major negative externalities on the natural environment. Below are some of the principal effects identified (see Table 5).

Table 5. The effects of industrialization and globalization on biodiversity

Process	Effects on biodiversity
Industrialization of agriculture (monocultures, pesticides, chemical fertilizers)	Eliminates spontaneous flora, kills pollinating insects, reduces genetic diversity.
Excessive urbanization	Habitat fragmentation, pollution, pressure on natural resources.
Economic globalization	Imports of alien/invasive species, genetic standardization, disappearance of local breeds.
Illegal logging and massive infrastructure	Loss of forests, interrupted ecological corridors, isolation of species populations.

Source: Created by the author based on analysis

Although industrialization and globalization have contributed significantly to economic development and the modernization of society, they often come with an ecological cost that is hard to ignore – habitat fragmentation, loss of native species, and genetic homogenization. In this context, the dilemma posed in the title – "Do we protect or do we destroy?" – becomes increasingly relevant, inviting us to reflect on the fragile balance between progress and conservation (see Table 6).

Table 6. Effects of natural, economic and social risk factors

Type of factor	Effect on biodiversity	Romanian example
Naturals	Climate change, drought, floods.	Danube Delta affected by salinization and lack of migratory fish.
Economic	Lack of funding for conservation, unbalanced agricultural policies.	Abandoned or degraded agricultural lands.
Sociable	Youth migration, loss of traditional knowledge, poor environmental education.	The disappearance of sustainable agro-pastoral practices in mountain areas.

Source: Created by the author based on analysis

These risk factors contribute to ecosystem destabilization through abrupt alterations to natural balance, reduction in species resilience, and increasing conflicts between economic activities and environmental conservation. In rural areas, depopulation, land abandonment or, conversely, intensification of agricultural exploitation lead to habitat loss and a reduction in local biodiversity. Additionally, extreme weather phenomena – exacerbated by climate change – impose extra pressure on vulnerable species and ecosystems already under stress.

These risk factors do not act in isolation, but manifest as multiple pressures that simultaneously influence biodiversity – often invisibly, but with profoundly cumulative, devastating effects on ecosystems.

In the end, one may ask: "Do these actions bring us closer to protection or to destruction?" At the same time, it is important to emphasize that our decisions – whether political, social, or economic – have the power to tip the balance in either direction.

Research limitations

One of the main limitations of this study lies in the impossibility of performing the simple regression as originally planned, because species occurrence data from the GBIF platform, particularly for Romania and agricultural areas, proved insufficient in terms of number, spatial distribution, and accuracy to support a robust statistical model.

In the scientific literature there are numerous reports showing that global biodiversity data platforms such as GBIF have significant gaps (spatial bias, lack of detailed taxonomy, incomplete geolocation data) which limit the usefulness of these data for regression analyses or precise predictions. For example, in studies concerning vascular plant diversity in China it was found that at fine spatial scales GBIF covers far less than the true biodiversity (Qian et al., 2018).

For this reason, the present analysis has focused on bibliometric analysis (using VOSviewer), recent socio-economic data, and local/descriptive observations which, although they do not provide the statistical rigor of a full regression model, allow for the identification of trends, risk factors, and opportunities for agricultural biodiversity in Romania.

5. Conclusions

Romania has enormous conservation potential, but biodiversity is sensitive to land-use decisions. The scientific literature and bibliometric analysis indicate increasing interest in agricultural biodiversity in Romania, shifting from classic ecosystems such as the Carpathians and the Danube Delta toward emerging themes like genetic conservation, farmland biodiversity, and sustainable land-use management.

The VOSviewer analysis revealed several dominant thematic clusters – terms like "biodiversity", "conservation", "ecosystems", and "forestry" – which appear frequently and centrally in the corpus of analysed articles, underlining existing research priorities.

Recent socio-economic data (number of farms, average size, farm structure) suggest very fragmented agriculture, with small farms forming the numerical majority. This structure may condition both the conservation of biodiversity and the potential for adopting sustainable practices.

One of the main limitations of this research was the inability to perform the simple regression promised in the abstract, due to the lack of sufficient GBIF species-observation data for Romaniaţs agricultural areas. This prevents the direct statistical estimation of the relationship between observed biodiversity and variables such as land use or agricultural inputs.

However, the descriptive analysis and socio-economic correlations add value by providing a useful contextual framework: they allow for the identification of regions and farm types that could be prioritized for conservation interventions and agricultural policies.

For future research, it is recommended to collect more consistent local data on species observations (e.g. pollinating insects, wild plants), integrate these data with socio-economic statistic, and, if sufficient data are obtained, perform regression analyses to test hypotheses regarding the impact of factors such as farming type, agricultural inputs, and farm structure on biodiversity.

Romania stands at a crossroads between exceptional biodiversity and the pressures of modernization. Without balanced measures, we risk shifting, in just a few decades, from protecting to destroying.

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