

Human Pressures, Community Perceptions and Biodiversity Conservation in the Danube Delta: Insights from a Socio-Ecological Survey

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Abstract

The Danube Delta Biosphere Reserve represents one of the most complex socio-ecological systems in Europe, where environmental pressures, traditional economic practices, and conservation policies interact in direct and often conflicting ways. This study examines residents' perceptions of the impact of human activities—fishing, agriculture, and tourism—on biodiversity, based on a survey conducted with a sample of 323 individuals from local communities. The results indicate a high level of awareness regarding ecological pressures: 76% of respondents attribute the decline of certain fish species to intensive fishing, 90% identify poaching as a major driver of degradation, 80% consider stubble burning the principal agricultural risk, and 81% support limiting boat traffic as a measure to protect habitats. At the same time, community perceptions reveal a structural ambivalence shaped by economic dependence on natural resources and by the restrictions associated with protected-area regulations. The analysis, framed within the pressures–perceptions–policies conceptual model, highlights the need for co-management policies that reconcile biodiversity protection with local development objectives. The findings underscore that long-term sustainability in the Danube Delta cannot be achieved without the active involvement of local communities in shaping conservation strategies and in the sustainable use of natural resources.

Keywords: *Biodiversity conservation; local community perceptions; socio-ecological systems; sustainable resource management; Danube Delta Biosphere Reserve;*

1. Introduction

Biodiversity, understood as the total variability of genes, species, ecosystems, and the ecological processes that sustain them, underpins the functioning of natural systems and the ecosystem services essential to human societies. Natural resources—water, soil, fauna, flora, and landscapes—hold intrinsic ecological value but also significant economic, social, and cultural importance for the communities that depend on them. In this sense, biodiversity conservation is not only an ecological obligation but also a fundamental requirement for maintaining long-term socio-economic stability. The Danube Delta, recognized as a Biosphere Reserve and Ramsar site, represents one of the most complex and dynamic socio-ecological systems in Europe. The region is distinguished by the profound interdependence between its natural components—habitats, species, and hydrological processes—and

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the cultural and economic structures developed by the multiethnic communities inhabiting it. Over time, these communities have built a rich cultural heritage in which traditions, crafts, vernacular architecture, traditional fishing, and folklore intertwine with the natural rhythms of the deltaic ecosystem.

Beyond its ecological functions, the Danube Delta possesses a deeply rooted economic and social vocation grounded in the traditional practices of its inhabitants. Historically, the relationship between agriculture and fishing has been a complementary one, shaped by the geomorphological characteristics of the territory. The fertile levees provided extensive natural pastures that supported large numbers of livestock—sheep, pigs, and cattle, some raised in semi-free systems—while the higher lands were cultivated with cereals and food crops. Although fish production has traditionally represented the primary economic resource of the Delta, agriculture has served as an essential and valuable component for ensuring food security and diversifying the livelihoods of rural communities (Lup et al., 2017).

The importance of fishing for the socio-economic structure of the region is also reflected in current legislation. According to Law no. 176/2024, commercial fishing is defined as the extraction of live aquatic resources from natural habitats for economic purposes, underscoring its crucial role in securing food and income for communities that rely directly on aquatic resources. Globally, commercial fisheries remain central to the livelihoods of millions and constitute one of the main sources of protein (Pila et al., 2023; Samofatova & Neveseliuk, 2020). This relevance is mirrored in the Danube Delta, where traditional fishing continues to represent the backbone of the local economy, functioning both as a commercial activity and as a core element of cultural identity.

However, the dynamics of the fisheries sector have changed significantly in recent decades. The decline of fish stocks in the Danube and deltaic habitats—caused by overexploitation, habitat degradation, and broader ecosystem changes—has led to reductions in catches and increased economic vulnerability for communities dependent on this activity (Neculiță & Moga, 2015; Hodoșan et al., 2023). Moreover, competition from imported fish products and changes in consumer demand have weakened the competitiveness of the local market, reducing opportunities for traditional fishers and complicating the transition toward sustainable fishing practices (Balaci et al., 2025).

Although secondary to fishing, agriculture plays a complementary role by contributing to economic diversification and community stability. The use of natural pastures, extensive livestock rearing, and cultivation of higher-elevation lands historically provided a stable economic and food-production base adapted to the ecological constraints of the Delta (Lup et al., 2017). Today, however, agricultural practices face additional challenges associated with protected-area regulations, climate change, and socio-economic pressures, highlighting the need for integrated natural resource management.

These dynamics reveal a defining characteristic of the Danube Delta: the structural interdependence among biodiversity, natural resources, and traditional production systems. Both fishing and agriculture rely on the integrity of the deltaic ecosystem (Herciu et al., 2011), while habitat degradation directly affects the quality of life and economic resilience of local communities. Consequently, integrating these traditional sectors into conservation and development strategies is indispensable for ensuring long-term sustainability.

At the same time, growing anthropogenic pressures—particularly from tourism—have introduced additional tensions in the relationship between communities and the natural environment. Studies indicate that mass tourism can exacerbate ecosystem degradation, alter local economic structures, and negatively influence residents' perceptions of conservation efforts when not properly managed (Mortz et al., 2005; Becken, 2013). Conversely, sustainable tourism, when well planned and embedded within local socio-cultural contexts, can provide significant income opportunities and support both biodiversity protection and cultural heritage preservation (Stylidis et al., 2014; Sinclair-Maragh et al., 2015).

Integrating cultural heritage into ecosystem conservation strategies is essential, as local traditions and occupations contribute to the sustainable use of natural resources. Traditional practices, transmitted across generations, offer adaptive solutions for biodiversity management that align with the socio-cultural specificities of the region. Furthermore, protecting and valorising cultural heritage can stimulate cultural and eco-tourism, thereby strengthening local identity and supporting diversified local economies (Mortz et al., 2005).

Tourism represents an important instrument for local economic development; however, as noted by Mortz et al. (2005), its benefits often come with environmental and cultural costs. In the Danube Delta, tourism-related pressures have increased significantly over the past decades due to growing resource demand from both residents and visitors, expanding accommodation capacity, and rising levels of pollution. As such, implementing sustainable tourism requires an equitable distribution of environmental, social, and economic costs and benefits (Twining-Ward & Butler, 2002). Strategic planning must also account for the increased consumption of energy, water, and land, as well as environmental degradation associated with transport and accommodation (Becken, 2013).

Thus, the Danube Delta constitutes a territory in which biodiversity, cultural heritage, fishing, agriculture, and tourism form an interdependent socio-ecological system characterized by tensions, vulnerabilities, and opportunities. Understanding these complex relationships is essential for formulating co-management policies capable of addressing both ecosystem conservation needs and socio-economic development goals. In this context, analysing local residents' perceptions of the impact of human activities on biodiversity offers indispensable insights for designing sustainable strategies in the Danube Delta.

2. Materials and methods

This study is based on the results of a quantitative research component conducted within a complex project funded by the European Union, whose primary objective was the revision of the Management Plan of the Danube Delta Biosphere Reserve. A central element of the project was the consultation of local communities, as integrating residents' perspectives is indispensable for grounding conservation measures and enhancing the effectiveness of management policies in protected natural areas.

In the context of biodiversity conservation, assessing local community perceptions is crucial for understanding the level of acceptance of species and habitat protection measures, as well as for identifying potential gaps in public awareness regarding the principles of sustainable development and the benefits of the area, including opportunities associated with agro-eco-tourism or community-based tourism.

The objective of this research is to analyse residents' attitudes toward anthropogenic pressures and threats that may influence both the ecological state of the Danube Delta and the socio-economic well-being of local communities. Investigating these attitudes is a complex endeavour, as they are strongly shaped by residents' perceptions of the efficiency of responsible authorities and by their assessments of the environmental, social, and economic impacts of the region's dominant activities—fishing, agriculture, and tourism. To explore the mental images, perceptions, and evaluations already formed among residents regarding these issues, a sociological survey based on a standardized questionnaire was conducted. The research instrument was administered to a sample of 323 respondents, selected to adequately represent the resident population of the protected area. Representativeness was ensured by considering relevant socio-demographic variables such as sex, age group, and occupational status.

The sample size was determined through a stratified sampling procedure, taking into account the desired level of precision and the confidence interval associated with statistical estimates. Accordingly, a tolerated error of $\pm 4.8\%$ was adopted at a 95% confidence level, parameters deemed appropriate given the size and heterogeneity of the target population.

Data collection was carried out through direct, face-to-face administration of the questionnaires, which increased the accuracy of responses and allowed for clarification of any potential misunderstandings on the part of respondents. This approach facilitated the acquisition of a robust and relevant dataset necessary for analysing local community perceptions and attitudes toward biodiversity conservation and the sustainable management of natural resources in the Danube Delta.

3. Results and discussion

The results of the survey conducted among communities in the Danube Delta Biosphere Reserve outline a complex picture of the relationship between residents and their natural environment—a relationship shaped by socio-economic pressures and the imperatives of biodiversity conservation (Mortz et al., 2005). Local communities find themselves in a moment of cultural and economic transition: although a significant part of traditional practices has been abandoned in recent decades, the core traditional occupations—fishing, animal husbandry, and agriculture—continue to form the backbone of the rural economy. Culturally, modernization has reshaped value systems and lifestyles, yet economically the dependence on the Delta's natural resources remains largely unchanged (Aivaz & Şerbănescu, 2024).

Within this dynamic, tourism is perceived simultaneously as an opportunity and as a source of risk (Pavel-Nedeia & Dona, 2017). An increasing share of the population views tourism as an alternative source of income, especially in communities with limited economic resources, but its acceptance is conditional on the adoption of responsible practices that do not threaten the natural or cultural heritage. The balance between the need for local development and the protection of habitats and species thus emerges as a central concern of residents.

Survey data show that community perceptions are strongly shaped by current ecological pressures. In the domain of fishing, 76% of respondents believe that intensive fishing is responsible for the decline of commercially valuable fish species, while 90% attribute a decisive role to poaching in degrading fish stocks. At the same time, 72% perceive the protection of certain piscivorous species, such as the great cormorant, as a threat to fish resources, suggesting a tension between conservation objectives and community interests. Despite these negative perceptions, nearly nine out of ten respondents (89%) believe that hydrotechnical interventions, such as dredging canals and lakes, can help restore spawning areas and migration routes, indicating a favourable orientation toward ecological restoration measures.

Fishers' general sentiment toward the protection regime is marked by ambivalence (Sumaila et al., 2014). On the one hand, restrictions are perceived as limiting access to fish resources and as administrative barriers that are difficult to overcome; on the other hand, there is noticeable support for maintaining clear seasonal and territorial regulations, as well as for establishing differentiated rights for local fishers. The perceived overlap of responsibilities among control institutions, bureaucratic procedures, and the absence of tailored financial instruments—such as low-interest loans or reduced VAT on fish products—contribute to the impression that existing policies are insufficiently aligned with the socio-economic realities of the Delta.

A similar ambivalence emerges in the agricultural sector. The majority of respondents (80%) perceive stubble burning as a major risk factor that can trigger fires and degrade natural habitats, while 78% explicitly support eliminating pesticide use from agricultural practices. These results indicate a high level of ecological awareness. However, 56% of residents point to the negative effects of abandoned domestic animals on habitats, reflecting challenges in resource management at the community level. Although many farmers view the protected area status as an opportunity for accessing European funding and developing sustainable agricultural practices, there is also a perception that imposed restrictions significantly limit earning potential, and that compensation for wildlife-related damages is insufficient.

In the tourism sector, the data reveal a clear perception of pressures on biodiversity. Approximately two-thirds of respondents (67%) believe that unauthorized access to protected areas has contributed to the decline of certain bird species, while 81% consider limiting the number of boats necessary to reduce impacts on aquatic ecosystems. Similarly, 79% find both excessive boating speeds and unrestricted tourist access to sensitive zones problematic, arguing for the need for specialized guidance. These results suggest a favourable orientation toward an ecological, controlled, and professionally guided tourism model.

However, perceptions of the role of tourism in the local economy (Zhang & Gao, 2016) are more nuanced. Communities recognize that tourism can stimulate other economic sectors and create markets for local products, but they also observe negative effects on quality of life, associated with increased numbers of tourists and pressure on infrastructure. Furthermore, the tourism sector is perceived as having only a modest contribution to the area's economy, indicating structural barriers to fully valorising the Delta's real potential.

Overall, integrating these findings within a theoretical perspective based on the pressures–perceptions–policies model allows for a coherent interpretation of the relationship between communities and their environment. Identified pressures—whether arising from resource exploitation, agricultural practices, or uncontrolled forms of tourism—directly influence local perceptions. These often ambivalent perceptions subsequently shape the acceptance or rejection of public policies. When policies fail to reflect local socio-economic realities or are perceived as overly restrictive, community behaviours may conflict with conservation objectives. Conversely, when communities are consulted and policies are flexible, adaptive, and developed through co-management mechanisms, the conditions for genuine collaboration between local actors and conservation authorities are strengthened.

The results thus suggest that the future of conservation in the Danube Delta depends on the ability of public policies to integrate local knowledge and perceptions, to recognize the value of traditional activities, and to develop

viable economic alternatives that reduce pressures on habitats. Only through such an integrated framework—addressing pressures, perceptions, and policies simultaneously—can a sustainable development model be established, in which biodiversity protection and community well-being become convergent rather than competing goals.

Contributions and limitations of the study

The study provides several relevant contributions to the literature on the governance of protected areas and the socio-ecological management of natural resources. First, the analysis offers an empirical perspective on the perceptions of local communities, highlighting the ways in which ecological pressures are internalised by social actors and how these shape the acceptance or contestation of conservation policies. Integrating the results into the pressures–perceptions–policies model represents an important conceptual contribution, as it enables a better understanding of the causal relationships between anthropogenic effects, social representations, and governance effectiveness.

Second, the study underscores the diversity of perceptions across economic sectors—fishing, agriculture, and tourism—clarifying how occupational specificities generate different expectations and conflicts in relation to protected area status. This sectoral approach is essential for designing differentiated policies tailored to the socio-economic realities of the Danube Delta.

However, the study also presents certain limitations. The cross-sectional survey design captures perceptions at a specific moment in time and does not allow for the observation of dynamic developments in socio-ecological relations. Additionally, the analysis relies on respondents' self-reported data, which may introduce perceptual or attitudinal biases. The survey does not include an in-depth qualitative component, such as semi-structured interviews, which could have facilitated a more nuanced interpretation of the relationship between communities and public policies. Despite these limitations, the results offer a solid basis for designing coherent interventions and for further research.

Policy recommendations

Based on the analysis of the results, the need emerges for public policies that harmonise conservation objectives with those of local socio-economic development. In the field of fishing, the recommendations aim at strengthening a co-management model between communities and authorities, whereby local fishers are directly involved in setting quotas, monitoring resources, and combating poaching. Simplifying permit procedures, providing access to low-interest financial instruments, and explicitly recognising traditional fishing as

an activity of cultural and ecological value may increase compliance and reduce conflicts.

In agriculture, policies should focus on promoting agroecological practices, eliminating pesticides, and ensuring responsible management of stubble fields. Expanding compensatory measures for damages caused by wildlife and supporting forms of association among farmers are essential for reducing socio-economic vulnerability and consolidating an agricultural model compatible with protected area status.

In the tourism sector, the results support the adoption of a model based on controlling tourist flows, limiting boat speeds, mandatory guiding in sensitive areas, and developing tourism infrastructure aligned with ecotourism principles. Policies should further encourage the development of authentic local products, seasonal diversification of the tourism offer, and the creation of local value chains so that economic benefits are equitably distributed within communities. Strengthening ecological education for both tourists and economic operators is also necessary to reduce pressure on habitats and promote responsible behaviour.

Overall, the recommendations emphasise the importance of participatory governance, in which communities are not merely beneficiaries of policies but active actors in their planning and implementation. Policies based on continuous dialogue, context-specific adaptation, and integrated monitoring can contribute to building a sustainable development model for the Danube Delta, where biodiversity conservation and community prosperity become convergent objectives.

4. Conclusions

The analysis of community perceptions in the Danube Delta Biosphere Reserve reveals a complex relationship between socio-economic development and biodiversity conservation, in which environmental pressures, residents' perceptions, and the effectiveness of public policies mutually influence one another. Survey results show that inhabitants are fully aware of ecosystem vulnerability, identifying intensive fishing, poaching, inadequate agricultural practices, and uncontrolled tourism as major drivers of degradation. At the same time, communities express strong concern for the sustainability of economic activities and support interventions that can contribute to ecosystem restoration and responsible use of natural resources.

Nevertheless, positive perceptions toward conservation are often in tension with the socio-economic realities of the region. Restrictions imposed by protected area status are perceived as limitations on access to resources, while the lack of policies tailored to local specificities generates frustration and distrust. Fishers, farmers, and tourism operators perceive protection policies as

insufficiently aligned with their economic needs, and existing support and compensation mechanisms are considered ineffective or difficult to access.

Within this context, tourism emerges as a sector with remarkable development potential, yet its success depends on the adoption of appropriate ecological and cultural models that mitigate habitat pressures and valorise local identity. The high level of acceptance for measures such as limiting the number of boats, guiding tourists, or regulating navigation speed suggests that residents are willing to support a responsible tourism model, provided they are actively involved in its design and implementation.

Integrating these findings into the pressures–perceptions–policies conceptual model suggests that sustainability in the Danube Delta cannot be achieved without the direct participation of local communities. Environmental policies that ignore residents’ perceptions risk being contested or generating adverse effects, whereas co-created, flexible policies oriented toward co-management mechanisms have the potential to reduce ecosystem pressures and increase social acceptance.

In conclusion, the sustainable development of the Danube Delta depends on articulating a governance framework that harmonises community needs with conservation objectives, valorises traditional knowledge, provides appropriate economic instruments, and strengthens the role of locals as active partners in protection efforts. Only through an integrated approach—in which pressures, perceptions, and policies are treated as components of the same socio-ecological system—can a balanced future be ensured for the Delta’s exceptional biodiversity and for the communities that depend on it.

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