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Territorial Challenges and Sustainable Regional Development

A mixed-method approach

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Introduction

Territories around the world have diverse characteristics and challenges. These are particularly evident in Italy, where most human settlements consist of small towns, all with different environmental, social, economic, and cultural features, especially when compared to large cities. This diversity implies not only challenges but also diversified strategies and policies at local level. In this context, Regional development as research branch is crucial. It puts *places* — where economic, social, and ecological processes exist — at the center of analysis and policy. Regional development also explains why economies concentrate, why disparities persist, and how place-based strategies can convert local assets into inclusive, sustainable growth (Capello and Nijkamp, 2009).

Nowadays, territories cope with climate exposure, resource consumption, land-use conflict, pollution and emissions that are produced locally but governed across fragmented scales. Negative environmental externalities, alongside benefits, make policy design difficult when spatial effects are ignored (Krugman, 1999). Many regions face demographic decline and ageing, selective out-migration of youth, and weakened social infrastructure, all of which erode local capabilities and the legitimacy needed for long-term investment. The result is a social penalty for marginalized territories, such as less involvement in decision-making, lower access to services, and reduced capacity to manage environmental risks — turning social fragility into environmental vulnerability (Jovovic et al., 2017). Economically, territories outside major hubs contend with thin markets, higher distance costs, and lock-in to narrow specializations that are hard to upgrade (Bogdański, 2012). In sum, territorial development is constrained by environmental risks, social fragility, and economic frictions. These challenges arise from how activities concentrate, how institutions distribute power and information, and how communities ascribe meaning to their landscapes. A regional development lens makes these dynamics visible and measurable—setting the stage for strategies that rebuild territorial capital, align with ecological limits, and engage cultures of place.

Within this perspective, *places* are meant not only as geographical, but foremost they are socially produced setting where meanings, identities, rules, and relationships are continually made and remade. *Placemaking*, therefore, is understood as a process that aligns physical interventions with practices and narratives of the people who inhabit a territory (Akbar and Edelenbos, 2021). Recent work reframes it as an iterative, multi-actor practice in which residents, civic groups, firms, and public agencies co-produce the uses and identities of spaces over time (Ellery et al., 2021). This shift — from product to process — highlights how "place" fuses built form with social ties, trust, and local capability, making placemaking a lever for community empowerment, social cohesion, and quality of life (Akbar and Edelenbos, 2021).

Places comprise both material settings (streets, squares, housing, services) and subjective attachments (belonging, memory, mutual recognition). This can be confirmed in Friedmann's reseach, where the role of residents in placemaking gives evidence that places are relational and political, not merely physical (Friedmann, 2007, 2010). This relational view is crucial: placemaking turns in politic activities in which actors assemble place-based and shared understandings that coordinate action across scales and networks (Pierce et al., 2011). For regional development, this means effective strategies connect local actors, narratives, and assets into wider circuits of collaboration and learning. From a economic point of view, placemaking can strengthen human capital, local amenities, and institutional capacity, enhancing welfare, improving living conditions and enabling productive density where it is most effective (Glaeser and Gottlieb, 2008).

Across marginalized territories, environmental degradation, social disaffection, and economic stagnation tend to co-evolve. In this context, the main coordination mechanism - namely the Market and the State - misfire when needs, ecology, and capabilities vary across places (Sacchetti and Borzaga, 2021). Markets underprovide when distance costs, thin demand, or hard-to-price externalities dominate; States underperform when uniform, top-down designs ignore local ecologies, capacities, and norms. In practice, many territorial problems sit in between these poles, where neither price signals nor central governance fit on place-based strategies. Following Elinor Ostrom's perspective, many territorial assets — water, landscapes, local public fields, even shared service systems — function as common-pool resources or local public goods (Ostrom, 1990): subtractable, interdependent, and hard to govern at distance. Durable governance emerges when institutions fit context and embody a set of design principles: clear use and resource boundaries, rules congruent with local conditions and proportional benefits, collective-choice rule-making, user - anchored monitoring, graduated sanctions, low-cost conflict resolution, recognition of the right to self-organize, and nested arrangements for larger systems (Ostrom, 2000). Treating placemaking as a social process—co-designing rules, uses, and stewardship with residents and local producers—converts fragmented initiatives into polycentric governance: multiple, overlapping decision centers with autonomy at appropriate scales, linked for recognition and conflict resolution (Ostrom, 2010). In regional development practice, this takes the form of shared administration, where public authorities partner with social-economy and community organizations to co-produce services and co-decide strategy (Sacchetti and Borzaga, 2021). This shift brings three key advantages. First, institution–context fit: rules are tailored to local ecologies and cultures, which lowers enforcement and coordination costs. Second, accountable monitoring and learning: user-anchored monitoring, graduated sanctions, and nested forums enable ongoing adjustment as conditions change. Third, internalizing governance externalities: by diffusing strategic control to affected publics, multi-stakeholder arrangements align organizational purpose with territorial welfare. Moreover, when it comes to spatial polarization issues, placemaking with and shared administration helps counter it by mobilizing local knowledge, tailoring services to need, and generating positive spillovers that benefit both public and private production (Sacchetti et al., 2023). In practice, these arrangements raise the effectiveness of per-capita public spending in peripheral areas, lower average production costs through locally created externalities, and produce positive externalities, as empowerment and participation, that strengthen performance and trust. In general, polycentric, placemaking-based systems reconnect localities to wider policy and market circuits, helping to overcome the main territorial challenges.

This perspective finds expression in sustainable development, where the social, economic, and environmental dimensions are closely intertwined. Sustainable development sets the overarching goal of balancing economy, society, and environment within ecological limits and intergenerational equity; sustainable regional development (SRD) is how that goal is operationalized in place — through regional, place-based strategies that align territorial capital with those triple aims (Capello and Nijkamp, 2009). At strategic and operational level, SRD privileges coherent place-based portfolios over piecemeal projects: (i) environmental regulation and ecosystem restoration to safeguard natural capital; (ii) inclusion and capability-building to widen opportunity sets; and (iii) competitiveness measures that serve—rather than override—social and ecological aims (Jovovic et al., 2017). Effective execution hinges on shared, value-driven leadership that bridges organizational boundaries and mobilizes coalitions across public, private, and civic actors. Evidence from rural regions shows that combining personal motivation, coalition-building, shared leadership, and institutional bricolage helps translate long-term sustainability ambitions into concrete interventions. Reading territories as nature–culture processes brings values, identities, and stewardship to the fore in planning and investment, improving policy fit and compliance (Dessein et al., 2016). SRD's instrument mix addresses failures while building capabilities: eco-compatible local economies (e.g., soft/heritage tourism, organic/agroecological production, circular practices) that valorize environmental quality without breaching limits; foundational infrastructure (transport, water/waste, broadband) that reduces distance costs and crowds in private activity; and participatory design and monitoring that institutionalize local knowledge and support adaptive learning. Empirical work in peripheral municipalities indicates that bundling these measures diversifies incomes, strengthens entrepreneurship, and improves service access—precisely where markets underinvest and uniform programs miss complementarities (Theodoropoulou et al., 2009).

The present work relies on territories diversity through a regional development lens. Building on this perspective, the thesis argues that environmental, social, and economic challenges in marginalized places are often symptoms of coordination gaps. The overarching aim is to develop a Sustainable Regional Development approach that balance three objectives: (i) quality of life and liveability of territories; (ii) effectiveness of policies for ecological protection of landscapes; and (iii) community participation in the design, delivery, and monitoring of policies.

The first chapter develops a decision-oriented diagnostic of liveability in the Italian Inner Areas, combining an SDG11-aligned composite index with meta-frontier benchmarking and spatial econometric analysis. Rather than simply ranking municipalities, the chapter distinguishes absolute performance from structural disadvantage by comparing group-specific frontiers to a common meta-frontier, and shows that disparities are more clearly expressed through the gap ratio than through meta-frontier efficiency alone. Spatial diagnostics and Spatial Durbin estimates further demonstrate that liveability outcomes are territorially interdependent: local performance is shaped not only by municipal characteristics but also by neighbouring contexts, with measurable spillovers and coherent hot-spot/cold-spot clusters.

The second chapter turns to ecological protection and asks whether a core ecological policy —Protected Areas (PAs) — reduces landscape fragmentation. Using a boundary-focused identification strategy, it estimates the local effect of protection at PAs edges across time. The results offer two policy-relevant messages: first, protection does curb fragmentation inside PAs; second, impacts attenuate immediately outside their borders. This combination points directly to how to design strategies in the places flagged by Chapter 1: pair protection with connectivity measures (buffers, corridors, cross-boundary planning) so conservation benefits extend across the regional system rather than remaining trapped within administrative lines.

The third chapter addresses the participation pillar by treating Protected Areas as social–ecological systems and examining how different governance arrangements shape outcomes. It shows that polycentric, shared-administration models—where public authorities co-produce rules and services with community and social-economy actors—lower distance and enforcement costs, internalize governance externalities, and build the local trust needed for durable compliance. In short, it translates participation from consultation into co-production, providing the institutional "technology" that Chapters 1 and 2 require to be effective in practice.

The thesis focuses on three provinces in central Italy—Rome, Rieti, and L'Aquila—chosen for their sharp internal contrasts, in both morphological and social features. The area ranges from the metropolitan core of Rome to rural and mountainous Apennine municipalities where settlements are small and often distant from essential services. This territory of study offers a compact laboratory of urban–rural gradients, inner-peripheral challenges, and rich conservation assets. Its diversity allows to test how liveability gaps can be diagnosed, how conservation rules perform at the margin, and how polycentric, participatory governance can align ecological integrity, community participation, and quality of life. The thesis thus contributes a Economic Policy view of regional development: treat place as the scale at which externalities are produced and can be governed; assemble place-based strategies screened for environmental limits and social equity; and implement them through polycentric, participatory governance that aligns incentives and information locally.

Each chapter follows a common structure to ensure clarity and comparability across the thesis. Title, abstract, and keywords open the chapter and state the problem and the scope. An Introduction then situates the work in its policy and academic context, reviews the relevant literature, identifies the gaps the chapter addresses, and previews its contributions. Where appropriate, a dedicated Theoretical framework section formalizes concepts and links them to testable implications. A Methodology section follows, detailing the proposed approach—its assumptions, identification strategy, data requirements, and implementation steps; next, an Empirical analysis applies the methodology to the territory of study, reporting results, sensitivity checks, and policy-relevant interpretations. Each chapter closes with Concluding remarks that synthesize the main insights, limitations, and implications for regional development and future research.

Chapter 1

Assessing Liveability: a spatial and metafrontier analysis on Inner Areas

[1] [2]

Abstract

This chapter evaluates municipal liveability in the Italian Inner Areas through a multidimensional framework aligned with SDG 11 and a place-based policy perspective. Liveability is measured by constructing Composite Indicators covering key social, economic and environmental dimensions, aggregated into a Liveability Composite Index using a Benefit-of-the-Doubt (BoD) approach. To account for heterogeneous territorial conditions, the analysis applies a meta-frontier framework, estimating group-specific frontiers (Urban, Intermediate, Peripheral) and an overall meta-frontier. This design separates absolute performance from structural disadvantage via a gap ratio measuring the distance between group frontiers and the common benchmark. Group comparisons on log-transformed outcomes show no statistically significant differences in meta-frontier efficiency, while significant differences emerge for the gap ratio: Peripheral municipalities exhibit a systematically larger distance from the meta-frontier than Urban and Intermediate areas. Spatial diagnostics (Moran's I on OLS residuals and Rao's score/LM tests) reveal strong spatial dependence, motivating estimation of a Spatial Durbin Model (SDM). SDM results confirm significant spillovers and demonstrate that both local attributes and neighbouring contexts shape liveability, as evidenced by direct and indirect impact decomposition and by local G_i^* hot-spot/cold-spot clustering. Overall, the chapter provides a replicable, decision-oriented diagnostic to support place-based strategies, showing that effective interventions should address structural constraints and be coordinated at the scale of territorial systems rather than isolated municipalities.

Keywords: *Inner Areas, Benefit-of-the-Doubt, Metafrontier Analysis, Spatial Lag Model, SDG11*

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[2]During the preparation of this work, the author used ChatGPT 5.2 in order to improve language. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

1.1 Introduction

The aim of this chapter is to assess how municipalities in the Italian Inner Areas perform in terms of "liveability". It provides a policy-oriented and context-sensitive assessment, distinguishing absolute performance from structural disadvantage and showing that outcomes are shaped by spatial spillovers, thereby indicating that effective interventions should target territorial systems rather than isolated municipalities.

A significant part of the Italian territory is characterized by small settlements, often located in mountain areas. The definition of these places, known as "Inner Areas", is based on their remoteness from Urban Poles, which are capable of providing essential services such as education, health, and public transportation. Inner Areas are also distinguished by their environmental and cultural resources and have undergone significant diversification due to natural processes and centuries of human influence. Inner Areas overs over 60% of the national territory and includes over four thousand municipalities (Andreoli and Silvestri, 2017), where about a quarter of the Italian population lives. The geographical and social marginalization of Inner Areas, in addition to the scarcity of public and private services, has led to a progressive depopulation from the 1950s, resulting into economic vulnerability (Brandano et al., 2023). However, despite the lack of adequate access to essential services that can lead to a kind of marginalization and inequality, Inner Areas prove to be strategically important to foster sustainable and inclusive growth at local and national levels (Pagliacci and Fasano, 2023). It is important to stress out that these territories often preserve a vast environmental and cultural heritage. Therefore, from a national perspective the significance of the Inner Areas is more pronounced when viewed through the lens of "potential economic development" (Moretto et al., 2022). Examining the vast demographic and territorial characteristics of Inner Areas immediately emphasizes the significant potential for collective economic development today, making their contribution crucial for stabilizing the trajectory of economic development of the nation. To address this issue, in 2014 (and later in 2021) the Italian government proposed a plan called the National Strategy for Inner Areas (SNAI, 2013, 2021), in which municipalities are classified according to their state of marginality. Also, a *place based* policy has been proposed, to develop new ways of multi-level local governance to cope with demographic challenges and address territorial needs. The classification proposed by SNAI consists of two parts: 1) Identification of the Central Poles (*Poles* and *Urban Belts*) according to their ability to provide the essential services mentioned above; 2) Classification of the remaining municipalities in 3 branches: *Intermediate*, *Peripheral* and *Ultraperipheral Areas*, based on distances from the Central Poles measured in travel time, as shown in the Table 1.1. Figure 1.1 shows the spatial distribution of Inner Areas.

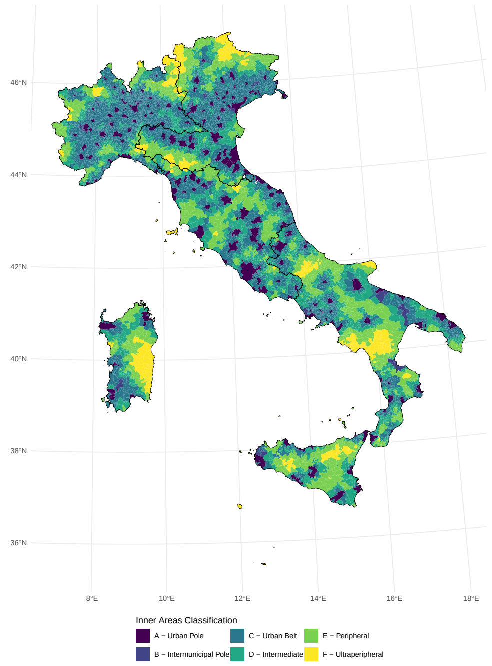


Figure 1.1: Spatial Distribution of Inner Areas. Source: SNAI (2021)

Italian Municipalities	
Centers	A - Urban Poles
	B - Urban belts
Inner areas	C - Intermediate areas (t <20')
	D - Peripheral areas (20' <t <75')
	E - Ultra-peripheral areas (t >75')

Table 1.1: Inner Areas classification expressed in travel time for essential services. Source: ACT (2020)

As a *place-based* integrated strategy aimed at reducing marginalization and demographic decline, the National Strategy attempts to create the preconditions for territorial development (adequate goods and essential services) and promote local development projects concerning five main areas of intervention:

1. Active territorial/environmental sustainability protection;
2. The valorization of natural/cultural capital and tourism;
3. The valorization of agriculture and food systems;
4. The activation of renewable energy supply chains;
5. Know-how and crafts.

The aim is to enhance the unexpressed or hidden territorial capital that distinguishes Inner Areas (Pagliacci and Fasano, 2023) with a thoughtfulness to consider these areas of intervention simultaneously, in order to respond to the needs of territorial communities in a comprehensive and sustainable approach (Meini et al., 2017). Clearly, the phenomenon of Inner Areas presents both challenges and opportunities. One major factor is progressive depopulation and aging, which many municipalities are experiencing (Caselli et al., 2020, Galderisi and Limongi, 2024). This process can result in the erosion of community life and to social and economic marginalization (Lucchetti et al., 2008, Vendemmia et al., 2023). This trend has been influenced in years also by geographical vulnerabilities, including the risk of natural disasters such as earthquakes or floods, and increasing the trend of populations displace (Dottori, 2024). Furthermore, the digital divide and difficulties in adapting to the market are barriers to growth and development. Several areas struggle to develop digital infrastructure, causing a substantial disadvantage in the national economy (Brandano et al., 2023). On the other side, an essential aspect in this framework is the involvement of local communities, in order to recognize the challenges of the territory and try to overcome the spatial polarization between urban and peripheral areas (Buffa et al., 2019, Sacchetti et al., 2023). As a result, virtuous processes can take place within limited resource contexts thanks to social innovation and models of sustainable development in community entrepreneurship (Cotella and Brovarone, 2022, Scaramuzzi et al., 2023, Splendiani et al., 2022) and in proximity economy (Mangano, 2023, Marotta and Nazzaro, 2023).

Therefore, urban and peripheral areas differ not only in geographical location, but also in levels of marginalization, quality of life, development potential and policy orientation (Kühn, 2015). Understanding these differences may be crucial for effective policy-making and planning.

1.2 Theoretical Background

Although the National Strategy draws attention to the diverse nature of solutions and challenges, some authors (Compagnucci and Morettini, 2024, Vendemmia et al., 2021) point out that the classification of Inner Areas is limited only to the travel time for essential services, encompassing the meaning of marginality only at distance. As stated in Máliková et al. (2016), marginality is a complex process influenced by social and economic changes, and it can lead to the uncertainty about the capacity of peripheral areas to achieve sustainable development (Chioni and Favargiotti, 2023). Sustainability has become the leading principle for shaping policies and development strategies worldwide. Within Europe, the European Union serves as the primary benchmark for sustainability policies, which must seamlessly integrate economic, social, and environmental factors (Paolotti et al., 2019). Nevertheless, assessing sustainable development is certainly a complex task, but is an essential consideration for policymakers (Boggia et al., 2018), necessitating a comprehensive evaluation of territorial dimensions, plus relationships between decision-making and spatial features of studied areas (Marić and Avdić, 2023). In general, a first step can be the construction of Composite Indicators and Indices (Sarra et al., 2024), as they can be useful to provide essential insights on the characteristics of some territory, as the grade of social inclusion (Giambona and Vassallo, 2014), the quality of life (Ustaoglu et al., 2023), the human development (Su et al., 2023).

When it comes to territorial polarization and marginalization, sustainable development encompasses a broad array of interconnected themes, including environmental protection, urban growth, economic resilience, and social equity. Addressing the impact of the urban-rural income gap on environmental health is essential, as income inequality can significantly affect environmental quality (He et al., 2023). Moreover, understanding the relationship between land use dynamics and ecosystem service values is also key to sustainable urban development. Integrating land use planning with ecosystem service preservation helps balance urban growth with environmental health, ensuring sustainable development (reza Abolmaali et al., 2024). Urban development and population dynamics are also central topics in achieving social sustainability. Exploring the drivers of population growth and decline, particularly in rural areas, is essential for formulating policies that foster balanced regional development and address rural depopulation (Ma et al., 2024). Such policies are vital for ensuring sustainable development in both urban and rural settings. The complex interactions between cities at different scales influence urban growth or shrinkage. Investigating these interactions is critical for developing regional urbanization strategies that promote sustainable urban growth and address the challenges of urban shrinkage (Ma et al., 2024), public health, and social equity (Bantie et al., 2024), and effective management of ecosystem services (Basu and Das, 2024). Economic resilience as well is fundamental for sustainable development. Strengthening the economic stability of regions, - particularly in smaller communities and non-metropolitan centers - is essential for diversifying economic strategies and fostering inclusive and sustainable local development (Crociata et al., 2024).

In the case of Inner Areas, the challenge is to make human settlements inclusive, safe, durable, and sustainable, thereby urging public, representative, and governing institutions to plan and guide their implementation, as stated in the Sustainable Development Goal 11 (SDG11): *Sustainable cities and Communities* (UN, 2024). The targets identified in this Goal include:

1. *Affordable and adequate housing.* This includes addressing informal settlements, overcrowding, insecure tenure, and improving housing conditions. The aim is to reduce the number of people living in slums and to cope with depopulation;

2. *Sustainable and accessible transport systems.* Cities need to offer safe, affordable, and sustainable transportation systems, by improving public transport, creating cycling and walking infrastructure, and reducing traffic congestion;

3. *Inclusive and safe public spaces.* Public spaces are vital for community well-being. They should be designed to be accessible, inclusive, and safe, encouraging social interaction and recreation;

4. *Cultural heritage enhancement.* Preserving and promoting cultural heritage in urban areas is essential for maintaining the identity and history of cities. This involves protecting historical buildings, monuments, and cultural landmarks, while integrating them into modern urban planning;

5. *Participatory urbanization.* Cities must promote inclusive decision-making processes that involve citizens in urban planning and governance. Participatory urbanization leads to more equitable, transparent, and responsive urban development that meets the needs of all citizens;

6. *Natural environment protection.* Communities should protect, restore, and enhance natural ecosystems. This involves sustainable urban development that minimizes environmental degradation, maintains biodiversity, and creates green infrastructure;

7. *Natural hazard reduction.* Cities should adopt measures to reduce the risks from natural hazards. Cities need to be designed and built to withstand natural disasters, ensuring that the poorest and most vulnerable populations are not disproportionately affected;

8. *Air quality and waste management.* Improving air quality and managing waste sustainably are critical to urban health and environmental sustainability. Efficient systems are essential for creating livable urban environments.

The focus on these targets is expressed not only at national level, but also regional and local. For this reason, according to the United Nations, it is crucial to support positive economic, social and environmental links between urban, peri-urban and rural areas (UN, 2024).

1.2.1 Composite indicators and sustainability assessment

Composite indicators are increasingly recognized as essential tools in sustainability assessment due to their ability to synthesize complex, multidimensional data into a single metric (OECD, 2008). In the context of corporate and environmental sustainability, these indicators integrate diverse domains—economic, environmental, social, and governance—into a unified framework that facilitates benchmarking, policy analysis, and strategic decision-making (Dočekalová and Kocmanová, 2016, Reig-Martínez et al., 2011). Their strength lies in their ability to translate intricate systems and performance dynamics into single index values, while retaining the capacity for disaggregated analysis through sub-indicators. This dual function enables organizations and policymakers to both track overall progress and identify specific areas of strength or concern. Furthermore, composite indicators help bridge the gap between scientific complexity and policy utility, simplifying communication without sacrificing nuance (Moffatt, 2008, Vollmer et al., 2016). Methodologically, approaches such as Multi-Criteria Decision Making (MCDM) and Data Envelopment Analysis (DEA) are increasingly employed to enhance the robustness and comparability of these indicators (Gibari et al., 2019). However, their effectiveness is not solely determined by technical soundness; rather, their influence in decision-making contexts depends significantly on user perception and institutional integration (Sébastien and Bauler, 2013). Composite indicators also play a crucial role in sustainability benchmarking and in informing the design of policies aimed at improving performance across sectors (Dočekalová and Kocmanová, 2016). As sustainability becomes a central concern in diverse fields—from agriculture to corporate governance to environmental management—the development and refinement of composite indicators is essential. Their ability to capture interdependencies and trade-offs, facilitate scenario analysis, and support strategic planning underscores their growing importance in guiding transitions toward more sustainable practices and policies.

Based on this theoretical background, this paper aims to contribute to the literature on Italy's Inner Areas, by answering the following questions: *How do composite indicators based on SDG11 targets capture the multidimensional nature of liveability in Inner Areas? How does their performance vary among different groups of municipalities and at spatial level*? The purpose is to obtain a brighter overview about the possible polarization between urban and rural environments and to provide an approach to rely on in policy interventions, directed at reducing possible discrepancies.

1.3 Methodology

1.3.1 Liveability Composite Index

In the present research work, Composite Indicators are computed through a weighted sum, where the weight is assigned using the *Entropy Weighting Method* (EWM), a type of objective method that is based on the distribution of data on the sample, in order to reduce the subjectivity of arbitrary weighting (Sarra et al., 2024, Su et al., 2023).

$$CI_i = \sum_{j=1}^{m} x^*_{ij} v^E_j$$

Where CI_i is the Composite Indicator at municipality i, x^*_{ij} is the standardized value of the variable j at ith observation (whith j as indicator and i as municipality), v^E_j is the weight assigned to the variable, and m is the number of variables. Variables are standardized using the MinMax approach (OECD, 2008), to make each value result between 0 and 1. Since some variables represent "undesirable outputs", the polaritiy in Table 1.2 were followed to optimize standardization, so that:

$$x^*_i = \begin{cases} \frac{x_i - min(x_i)}{max(x_i) - min(x_i)} & \text{if polarity} = + \\ 1 - \frac{x_i - min(x_i)}{max(x_i) - min(x_i)} & \text{if polarity} = \textbf{-} \end{cases}$$

In such way, it is possible to assign a better performance to higher values where the variable must be maximized or to lower values where they must be minimized (Ustaoglu et al., 2023).

Concerning the weighting system, the idea is that the higher the entropy of a variable (Karagiannis and Karagiannis, 2020), the more dispersed the information is, and hence, the variable contributes less to the decision. This approach can help to control any issue due to the availability of data, by optimizing the variables in use. Entropy is calculated as follows:

$$E_j = -k \sum_{i=1}^{N} p_{ij} \ln(p_{ij})$$

Where:

- $p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{N} x_{ij}}$ is the normalized value x of variable j at the ith alternative (observation), with N being the number of alternatives (sample size);
- $k = \frac{1}{\ln(N)}$ is a constant to ensure the entropy value is normalized between 0 and 1.

The weights for each variable are calculated as:

$$v^E_j = \frac{1 - E_j}{\sum_{j=1}^{m} 1 - E_j}$$

Where m is the number of variables and $1 - E_j$ is the degree of diversification, which indicates how much of data is non-random or informative.

Afterwards, results are aggregated into a single Index, here called *Liveability Composite Index* (LCI), which is calculated with Benefit-of-the-doubt (BoD) approach, using the Composite Indicators as outputs. BoD is widely used in tech and finance field (Gulati et al., 2024), but it can also be used to assess sustainability through indices (Giambona and Vassallo, 2014, Giambona et al., 2024). It is also an established method for aggregating indicators (Walheer, 2024) and is used to build indices as Human Development Index (OECD, 2008).

1.3.2 Metafrontier analysis

To assess whether are differences between groups of municipalities (Karagiannis and Karagiannis, 2018), the Meta-frontier Analysis is adopted. This is a method used in the field of efficiency and productivity analysis to compare the performance of different groups (regions, technologies, firms, etc.) that operate under different production environments or technologies (O'Donnell et al., 2008, Walheer, 2023). Using Meta-frontier analysis to study differences among groups of municipalities — such as urban and peripheral — can provide insights into how different environments and access to technology, resources, and infrastructure impact the efficiency and productivity of these cities. To apply Meta-frontier to the present study, the following steps has been carried out:

- First, it is necessary to compute the Group Frontier (LCI_i^G). This is the result of the Composite Index calculated for every group in analysis, so that every group has its own benchmark.

$$LCI_i^G = \frac{\sum CI_i^G w}{max \sum CI_i^G w}$$

- Then, the Meta-frontier (LCI_i^M) is calculated, as the general performance of the complete sample.

$$LCI_i^M = \frac{\sum CI_i^M w}{max \sum CI_i^M w}$$

- Once both are calculated, the *Liveability Gap Ratio* (LGR) can be computed, as a measure that quantifies the difference between the group-specific frontier and the Meta-frontier. The closer the LGR is to 1, the smaller is the gap between the Meta-frontier and the group-frontier. It is calculated as follows:

$$LGR_i = \frac{LCI_i^M}{LCI_i^G}$$

In this case, the weighting is not assigned on the basis of the distribution of data, yet is calculated to optimize the score of BoD. For this reason, it may occur that several DMUs could show a score of 1, leading to a biased result.

efficiency scores are log-transformed in order to mitigate the strong right-skewness inherent in frontier-based indicators and to better approximate normality. This transformation improves the statistical properties of the dependent variable and allows the use of parametric inference when comparing groups of municipalities.

Based on the log-transformed scores, Analysis of Variance (ANOVA) is employed to test whether there are statistically significant differences in mean efficiency levels across groups. ANOVA evaluates the null hypothesis that group means are equal against the alternative that at least one group differs:

- H_0: *the means of the different groups are equal*
- H_1: *at least one group mean is different*

When the ANOVA F-test indicates statistically significant differences (p-value < 0.05), post-hoc pairwise comparisons are conducted to identify which specific groups differ.

1.3.3 Spatial analysis

As a final step of the analysis, and in response to the reviewer's comments concerning the justification and interpretation of spatial econometric methods, efficiency scores are analyzed within a spatial regression framework (Ward and Gleditsch, 2018). The objective is to assess whether liveability outcomes exhibit spatial dependence and, if so, to identify the most appropriate spatial specification. In territorial systems, municipalities cannot be considered independent observational units: policies, infrastructure, service provision, and socio-economic conditions in one municipality may generate externalities that affect neighboring areas. Ignoring such interdependencies may therefore lead to biased estimates and misleading inference.

The empirical strategy proceeds in two stages. First, a conventional (aspatial) regression model is estimated, including a set of relevant socio-economic and geographic covariates. Second, a battery of spatial diagnostic tests is performed to detect the presence of spatial dependence and to motivate the use of a spatial econometric model.

Specifically, Moran's I test is applied to the residuals of the baseline model. This test assesses whether residuals exhibit systematic spatial autocorrelation, that is, whether nearby municipalities tend to display similar unexplained deviations. A statistically significant Moran's I indicates that the independence assumption underlying the aspatial model is violated and that spatial effects remain unaccounted for.

Conditional on the presence of residual spatial autocorrelation Rao's Score tests, also known as Lagrange Multiplier (LM) tests (Anselin, 1988, Rao, 2009), are employed to further investigate the nature of spatial dependence. In particular, LM tests for spatial lag and spatial error dependence are computed. These tests do not impose a specific spatial structure ex ante, but rather assess whether spatial dependence is more consistent with interaction effects among municipalities (i.e., spillovers in outcomes) or with unobserved spatially correlated factors captured in the error term. The use of Rao's Score test is essential to avoid model misspecification and to provide a statistically grounded motivation for adopting a spatial econometric framework.

The joint evidence provided by Moran's I and the LM tests supports the inclusion of spatial effects in the empirical analysis. Accordingly, the estimation proceeds with a spatial regression model, while the choice of the specific spatial specification is informed by the results and robustness checks discussed in the Results section.

The generic spatial model can be written as:

$$\mathbf{y_i} = \rho W \mathbf{y_i} + X_i \beta + W X_i \theta + \varepsilon_i$$

where $\mathbf{y_i}$ denotes the Benefit-of-the-Doubt (BoD) liveability score of municipality i, W is the spatial weights matrix, X_i is a vector of covariates, and ε_i is an idiosyncratic error term. The parameters ρ and θ capture, respectively, spatial dependence in the dependent variable and spatial spillovers associated with explanatory variables. This general formulation encompasses several commonly used spatial models, which are discussed and evaluated empirically in the Results section.

The spatial weights matrix is constructed using a row-standardized contiguity structure. Let w_{ij} denote the element of the binary contiguity matrix:

$$w_{ij} = \begin{cases} 1 & \text{if municipalities } i \text{ and } j \text{ share a common border} \\ 0 & \text{otherwise} \end{cases}$$

$$W_{ij} = \frac{w_{ij}}{\sum_{j=1}^{n} w_{ij}}$$

The vector of covariates X_i includes population density ($PDENS$), per capita income ($INCPC$), and elevation ($ELEV$) of each municipality. Population density is included to capture agglomeration effects and scale-related advantages in service provision, infrastructure availability, and access to opportunities, which are known to influence liveability outcomes. Per capita income reflects local economic capacity and fiscal resources, capturing differences in purchasing power, public service financing, and overall material well-being across municipalities. Elevation is introduced as a proxy for morphological and accessibility constraints, as mountainous and high-altitude areas often face higher infrastructure costs, greater exposure to natural hazards, and structural disadvantages in service delivery. Together, these variables allow to control for key socio-economic and geographic factors that may affect liveability independently of spatial interactions.

Within this framework, the presence and magnitude of spatial effects are interpreted as evidence of territorial interdependence in liveability performance. The decomposition of spatial impacts and the identification of direct and indirect (spillover) effects are addressed explicitly in the Results section through the estimation of the Spatial Durbin Model.

In order to observe spatial differences, it is also performed the Getis-Ord $Gi*$ statistic (Getis and Ord, 1992), which provides a measure of local spatial association that includes the target location, making it more sensitive to local clustering:

$$G_i^* = \frac{\sum_j W_{ij} x_j - \overline{X} \sum_j W_{ij}}{S \sqrt{\frac{\sum_j W_{ij}^2 - (\sum_j W_{ij})^2}{n-1}}}$$

With G_i^* being the local $Gi*$ statistic for location i, x_j being the value of the variable of interest at location j, W_{ij} being the spatial weight between location i and location j (based on a contiguity matrix), $\bar{X}$ being the mean of the variable, S being the standard deviation, and n being the number of neighbors of i.

$Gi*$ can be used to identify clusters of high or low values in spatial data, as some areas may exhibit higher or lower levels of values. By using Getis-Ord statistic, it is possible to identify where *hotspots* (areas with high values surrounded by other high values) and *coldspots* (areas with low values surrounded by other low values) are located, giving insights on patterns and spatial correlation in certain areas.

This approach allows for deeper insights into whether disparities in liveability are due to internal inefficiencies within each group or due to broader differences between groups. This can guide targeted policy interventions to bridge gaps and promote balanced local development.

1.3.4 Case study and data collection

As a case study, 298 municipalities were selected from three provinces (Figure 1.2) in central Italy, namely Rome (RM), Rieti (RI) and L'Aquila (AQ). Data used in the analysis refer to a singolar cross-section (2021).

As shown in Figure 1.3, the territory is composed by 7 Poles, 48 Urban belts 156 Intermediate areas, 84 Peripheral areas, 3 Ultra-peripheral areas. The territory of these three provinces presents highly diversified geographical and social features, from the metropolitan area of Rome to scattered villages in mountainous areas of the Apennines. To reduce the effect of the small size of some classes of sample, municipalities were aggregated into three main groups (Figure 1.3): *Urban*, *Intermediate*, *Peripheral* (UN, 2024).

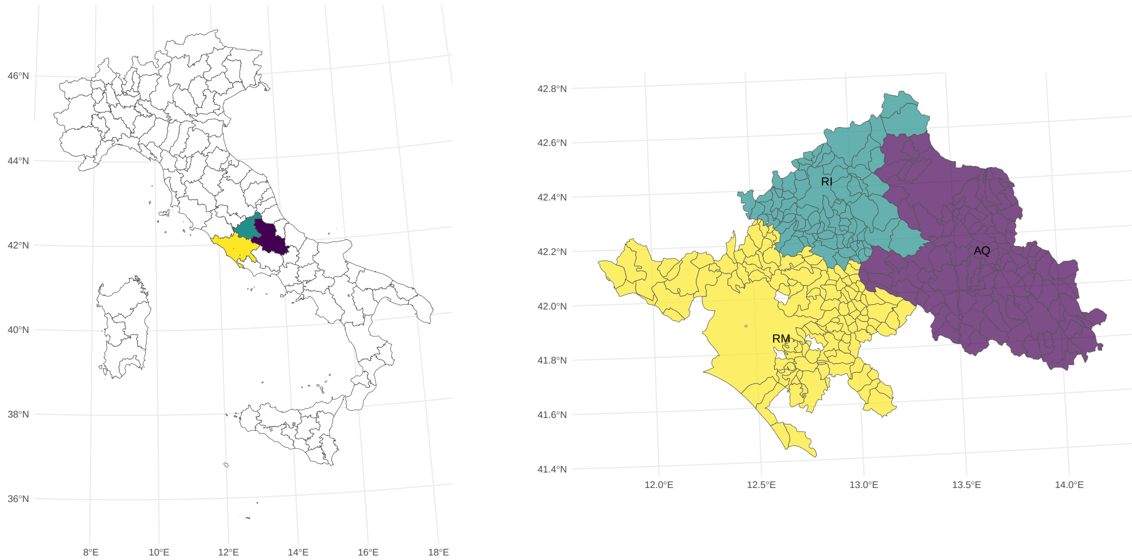


Figure 1.2: Case study location and municipalities. Source: ISTAT (2018)

Data were collected from open online databases, mainly from the National Institute of Statistics (ISTAT, 2023, 2024a,b,c) for demographic, economic and social variables, from the Territorial Cohesion Agency for the classification of Inner Areas 2021-2027 (ACT, 2020), from the Public Administration Database for public expenditures of municipalities (OpenBDAP, 2021), and from the European Environmental Agency for some environmental data (EEA, 2022). Table 1.2 shows the choice of indicators according to the targets of SDG11, while Figure 1.4 shows the spatial distribution of the covariates as socio-economic and geographical features. Data were then processed with R software, in particular with the packages *dplyr* for dataset cleaning (Wickham et al., 2023), *sf* for spatial data processing (Pebesma, 2018), *sfdep* for calculation of spatial clusters (Parry and Locke, 2024), *spatialreg* to perform Spatial Lag Models (Bivand and Piras, 2015), and *ggplot2* for plotting results and maps (Wickham, 2016).

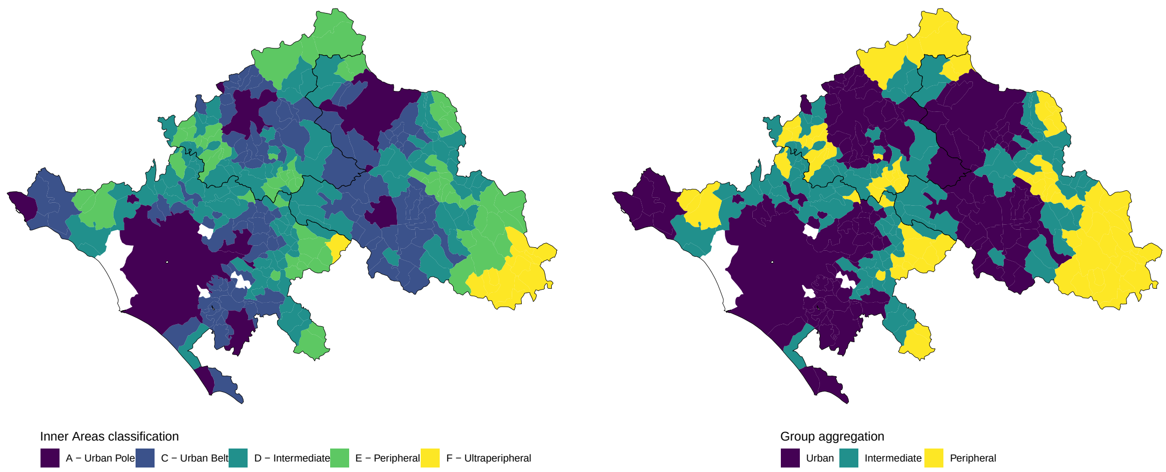


Figure 1.3: SNAI classification and group aggregation. Source: own elaboration from ACT (2020), SNAI (2021)

Composite Indicator	Variable	Description	Polarity	Weight (EWM)	Source
SETT **(Settlements conditions)**	pgr7121	Population growth rate (1971-2021)	-	0.578	ISTAT (2024b)
	esamin	Accessibility for essential services (travel time in min)	-	0.168	ISTAT (2023)
	pb80	Percentage of buildings constructed before 1980	-	0.524	ISTAT (2024b)
MOB **(Mobility)**	pbtrden	Pubilc transportation facilities density per km2 (train + bus)	+	0.895	ISTAT (2024b)
	slope	Terrain Steepness Index	-	0.053	ISTAT (2024c)
	rough	Terrain Roughness index	-	0.052	ISTAT (2024c)
PURB	urbr	Ratio between population growht and soil consumption (2015-2021)	+	0.152	ISTAT (2024b)
(Participatory urbanization)	democr	Percentage variation in participation in the last election round	+	0.848	ISTAT (2024b)
CULT **(Cultural Enhancement)**	cults1k	No. Cultural sites per 1000 inhabitants	+	0.287	ISTAT (2024b)
	visit1k	No. Visitors in cultural sites per 1000 inhabitants	+	0.427	ISTAT (2024b)
	cultexp	Per capita public expenditure for cultural enhancement	+	0.286	OpenBDAP (2021)
SEC	secexp	Per capita public expenditure for social security	+	0.521	OpenBDAP (2021)
(Social security)	avexp	Expenditure foranti-violence centers and women's shelters per 1000 women	+	0.479	ISTAT (2024b)
ENV	paperc	Protected Areas surface percentage (km2)	+	0.209	ISTAT (2024b)
(Environmental protection)	envexp	Per capita public expenditure for environmental protection	+	0.791	OpenBDAP (2021)
HAZ	hydrohaz	Percentage of municipal surface exposed to mid-high hydrogeological hazard (km2)	-	0.651	ISTAT (2024b)
(Natural Hazard)	lndslhaz	Percentage of municipal surface exposed to mid-high landslides hazard (km2)	-	0.349	ISTAT (2024b)
POLL **(Pollution)**	uswprod	Per capita unsorted solid waste production (kg)	-	0.411	ISTAT (2023)
	PM10	Per capita exposure to atmospheric particulate PM10 ($\mu g/m^3$)	-	0.309	EEA (2022)
	PM25	Per capita exposure to atmospheric particulate PM2.5 ($\mu g/m^3$)	-	0.28	EEA (2022)

Table 1.2: Composite Indicators, variables, polarity and weights

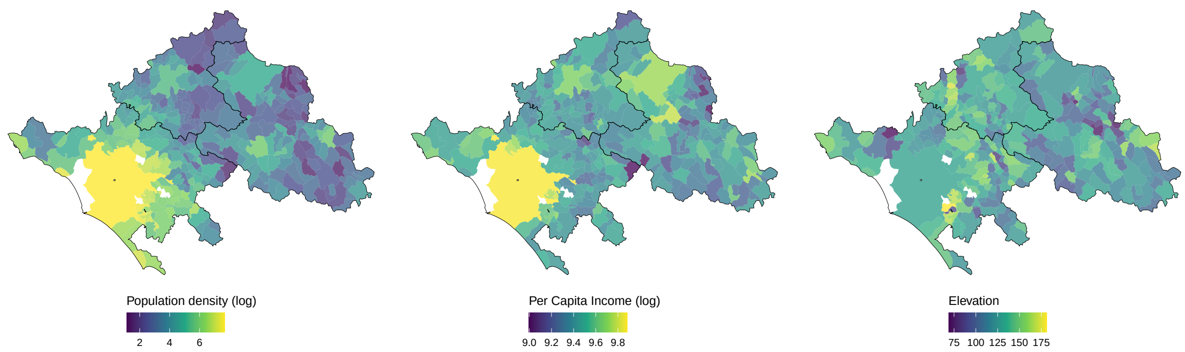


Figure 1.4: Spatial distribution of covariates. Source: own elaboration from ACT (2020), EUROSTAT (2018)

1.4 Results and discussion

1.4.1 Results

This section presents the main findings from the empirical analysis, which includes the construction of the Liveability Composite Index (LCI), efficiency evaluation using both group-specific and meta-frontiers, and spatial modeling through the Spatial Lag Model. The aim is to explore spatial patterns of liveability across municipalities in the provinces of Rome (RM), Rieti (RI), and L'Aquila (AQ), and to assess how different territorial contexts influence efficiency levels and inter-group disparities.

Descriptive statistics of the Composite Indicators are summarized in Table 1.3. The results reveal substantial heterogeneity across indicators and municipalities. The highest average values were recorded for the indicators related to Natural Hazards (HAZ; mean = 0.899) and Pollution (POLL; mean = 0.881), indicating consistent performance in environmental dimensions. Participatory Urbanization (PURB) also reported a relatively high mean (0.518), suggesting moderate effectiveness in managing population growth relative to land use. Conversely, Cultural Enhancement (CULT) and Social Security (SEC) displayed the lowest means (0.041 and 0.031 respectively), accompanied by high variability. This suggests that these domains are unevenly distributed and may reflect localized efforts or constraints in public cultural investments and welfare provisioning. Mobility (MOB), with a mean of just 0.088, highlighted the widespread inadequacy of transportation services, especially in peripheral and mountainous areas.

CI	Mean	StDev	Min	1st Quart	Median	3rd Quart	Max
SETT	0,369	0,165	0,089	0,247	0,326	0,444	1
MOB	0,088	0,107	0,004	0,036	0,051	0,081	1
PURB	0,518	0,117	0,081	0,465	0,550	0,568	1
CULT	0,041	0,096	0,000	0,000	0,000	0,038	1
SEC	0,031	0,107	0,000	0,000	0,000	0,000	1
ENV	0,090	0,102	0,000	0,011	0,057	0,150	1
HAZ	0,899	0,129	0,348	0,848	0,955	0,985	1
POLL	0,881	0,117	0,309	0,841	0,926	0,961	1

Table 1.3: Summary statistics of Composite Indicators

Table 1.4 reports descriptive statistics for the meta-frontier score (MF), group-frontier score (GF), and the gap ratio (GAP). MF is high on average (mean 0.963; median 0.980), but with a non-negligible lower tail (min 0.643), indicating that a subset of municipalities remains substantially distant from the overall best-practice benchmark. GF is slightly higher (mean 0.970), and also shows a lower tail (min 0.694), reflecting within-group heterogeneity. The gap ratio is close to one for most observations (median 0.998; 3rd quartile 1.000), yet its minimum (0.865) indicates that for some municipalities the group-specific frontier lies meaningfully below the meta-frontier benchmark. In operational terms, this distribution supports the use of the gap ratio as a separate outcome capturing structural distance between group benchmark conditions and the overall benchmark, rather than simply re-stating absolute efficiency levels.

Variable	Mean	StDev	Min	1st Quart	Median	3rd Quart	Max
Meta-frontier	0.9631	0.0494	0.6430	0.9502	0.9796	0.9948	1.0000
Group frontier	0.9701	0.0453	0.6943	0.9600	0.9873	1.0000	1.0000
Gap Ratio	0.9926	0.0155	0.8648	0.9927	0.9978	1.0000	1.0000

Table 1.4: Descriptive statistics of Meta-frontier analysis

Following the methodological choice to log-transform efficiency scores (to mitigate right-skewness and improve the suitability of parametric inference), Table 1.5 reports one-way ANOVA results across BRANCH groups (Urban, Intermediate, Peripheral). For the log-transformed meta-frontier score, the group effect is not statistically significant (F = 1.663; p = 0.191), suggesting no detectable mean differences across groups in absolute meta-frontier performance at conventional thresholds. In contrast, the group effect is statistically significant for the log-transformed gap ratio (F = 6.389; p = 0.00192), indicating that structural distance from the meta-frontier differs across territorial contexts. The post-hoc test (Tukey Honestly Significant Differences) results in Table 1.6 show that the relevant contrasts are those involving Peripheral municipalities: Peripheral–Urban and Peripheral–Intermediate differences are both around -0.49 on the log scale and statistically significant (adjusted p-values ≈ 0.004), whereas Intermediate–Urban is near zero and not significant. As a descriptive implication of effect size, a difference of -0.49 in log terms corresponds to a multiplicative factor of approximately $\exp(-0.49) \approx 0.61$ in the original scale (i.e., Peripheral values are notably lower in the gap-ratio measure), though the substantive interpretation is developed in the Discussion subsection.

Outcome	Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Meta-frontier (log)	Group	2	7.50	3.735	1.663	0.191
	Residuals	295	662.80	2.247		
Gap Ratio (log)	Group	2	13.42	6.712	6.389	0.00192**
	Residuals	295	309.91	1.051		

Table 1.5: One-way ANOVA results for group differences in efficiency scores

Comparison	Diff	Lower	Upper	Adj. p-value
Intermediate – Urban	0.002	-0.320	0.3251	0.999
Peripheral – Urban	-0.490	-0.852	-0.127	0.004**
Peripheral – Intermediate	-0.492	-0.853	-0.131	0.004**

Table 1.6: Tukey HSD post-hoc comparisons for Gap Ratio across Groups (95% family-wise confidence level)

Table 1.7 reports OLS estimates for both dependent variables using log(PDENS), log(INCPC) and $ELEV$. Formally, the baseline regression model is:

$$\mathbf{y_i} = \beta_0 + \beta_1 \log(\text{PDENS}_i) + \beta_2 \log(\text{INCPC}_i) + \beta_3 \text{ELEV}_i + \varepsilon_i,$$

where $\mathbf{y_i}$ denotes alternatively the log-transformed Meta-frontier score or the log-transformed gap ratio, $\log(\text{PDENS}_i)$ captures agglomeration and scale effects, $\log(\text{INCPC}_i)$ captures local economic capacity, and ELEV_i proxies morphological and accessibility constraints. In the meta-frontier model, log(PDENS) is positive and highly significant (0.306; $p < 0.001$), while log(INCPC) and ELEV are not significant at conventional levels. Overall fit is modest (Adj. $R^2 = 0.074$), yet the model is statistically significant (F-test p-value 1.15×10^{-5}), indicating that baseline structural covariates explain a non-trivial but limited share of variation in log(MF). In the gap-ratio model, coefficients are small and statistically insignificant, with near-zero explanatory power (Adj. $R^2 = -0.006$; F-test $p = 0.774$). This contrast between the two outcomes is an important empirical feature: while absolute meta-frontier efficiency is partially aligned with basic structural covariates, the gap ratio is not well described by the same aspatial linear specification.

	Meta-frontier model	Gap ratio model
OLS Results		
Intercept	11.609 (6.194)	2.220 (4.485)
log(PDENS)	0.306*** (0.065)	−0.001 (0.047)
log(INCPC)	−0.992 (0.665)	0.304 (0.481)
ELEV	0.004 (0.004)	0.002 (0.003)
Residual SE	1.446	1.047
R^2	0.083	0.004
Adj. R^2	0.074	−0.006
F-statistic (df)	8.904 (3, 294)	0.372 (3, 294)
Model p-value	1.15×10^{-5}	0.7736
Moran's I test on OLS residuals		
Moran's I (observed)	0.174	0.169
Expectation	−0.007	−0.007
Variance	0.00131	0.00131
Std. deviate (z)	4.993	4.857
p-value	2.97×10^{-7}	5.95×10^{-7}
Rao's score (Lagrange Multiplier) diagnostics		
RSerr	22.102***	20.866***
RSlag	17.117***	21.450***
adjRSerr	9.668**	1.357
adjRSlag	4.683*	1.941
SARMA	26.785***	22.807***

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $p < 0.10$.

Table 1.7: OLS estimates and spatial dependence diagnostics (Metafrontier vs Gap ratio)

Moran's I tests on OLS residuals (Table 1.7) are positive and highly significant for both models (observed Moran's I ≈ 0.17; z-statistics ≈ 4.86–4.99; p-values $< 10^{-6}$), showing that residual spatial autocorrelation persists even after controlling for population density, per-capita income, and elevation. This evidence indicates that the independence assumption underlying the aspatial specification is violated and that municipalities are embedded in interdependent territorial systems where liveability outcomes (and/or omitted factors) co-vary across space. Therefore, a spatial econometric model is required both to obtain reliable inference and to explicitly account for cross-border interactions consistent with the aim of the chapter. Rao's score (Lagrange Multiplier) diagnostics provide further guidance on the nature of spatial dependence. For the meta-frontier model, both the lag and error LM tests are significant and their robust versions remain significant (adjRSerr p = 0.0019; adjRSlag p = 0.030). Taken together, these patterns suggest that spatial dependence is present, but that it cannot be attributed unambiguously to a single mechanism (pure lag or pure error) across outcomes. In this context, adopting a more general specification that accommodates both outcome dependence and spatially mediated covariate effects is methodologically appropriate. Accordingly, the analysis proceeds with a Spatial Durbin Model (SDM), which augments the spatial lag structure with spatially lagged covariates (Koley and Bera, 2024), allowing the model to capture: (i) endogenous interaction effects in the dependent variable (i.e., outcome spillovers), and (ii) exogenous interaction effects transmitted through neighbouring socio-economic and geographical conditions (i.e., contextual spillovers). The SDM is specified as:

$$\mathbf{y_i} = \rho \mathbf{W} \mathbf{y_i} + \mathbf{X_i} \boldsymbol{\beta} + \mathbf{W} \mathbf{X_i} \boldsymbol{\theta} + \boldsymbol{\varepsilon_i},$$

where $\mathbf{y}$ denotes alternatively $\log(MF)$ (the log of the meta-frontier score) or $\log(GAP)$ (the log of the gap ratio), $\mathbf{W}$ is the row-standardized contiguity matrix, and $\mathbf{X}$ = [log(PDENS), log(INCPC), ELEV] includes population density, per-capita income, and elevation. Within this framework, ρ measures the strength of spatial dependence in outcomes, while $\boldsymbol{\theta}$ captures spillovers associated with the covariates, thereby providing a coherent empirical representation of territorial interdependence in liveability efficiency.

Table 1.8 reports Spatial Durbin Model (SDM) estimates. In both models, the spatial autoregressive parameter ρ is positive and highly significant (MF: 0.350; GAP: 0.335), and likelihood-based tests reject $\rho = 0$ (LR and Wald p-values $< 10^{-4}$). Relative to OLS, AIC improves substantially in both cases (MF: 1064.70 $\rightarrow$ 1047.50; GAP: 877.68 $\rightarrow$ 862.21), indicating better in-sample support for the spatial specification. The LM test for residual autocorrelation is not significant for the meta-frontier model (p = 0.146) and is marginal for the gap-ratio model (p = 0.073), suggesting that spatial structure is largely captured by the SDM. Coefficient patterns differ across the two outcomes. In the meta-frontier SDM, log(PDENS) is positive and significant, while its spatial lag W log(PDENS) is negative and significant; similarly, log(INCPC) is negative and significant while W log(INCPC) is positive and significant. In the gap-ratio SDM, the clearest evidence concerns the spatially lagged density term (negative and significant), while several local coefficients are weaker and not statistically significant.

Because SDM coefficients embed spatial feedback, Table 1.8 reports direct, indirect and total impacts. For the meta-frontier model, log(PDENS) shows a large positive direct effect (0.4905) and a sizeable negative indirect effect (-0.4071), yielding a small net total effect (0.0835). log(INCPC) displays the opposite structure: a negative direct effect (-1.8746) and a large positive indirect effect (4.4867), producing a positive total effect (2.6121). Elevation effects are comparatively small in magnitude in both models, although indirect components contribute non-trivially to totals. For the gap-ratio model, total density effects are negative (total -0.1240), while income total effects are positive (2.1098), again reflecting that spillovers (indirect effects) are material for understanding the association between covariates and outcomes under spatial dependence.

	Metafrontier model	**Gap ratio model**
Spatial Durbin Model coefficients		
Intercept	-14.635 (9.325)	-9.955 (6.855)
log(PDENS)	0.512^{***} (0.106)	0.133 (0.078)
log(INCPC)	-2.110^{**} (0.691)	-0.142 (0.506)
ELEV	0.003 (0.004)	0.001 (0.003)
W log(PDENS)	-0.458^{***} (0.135)	-0.215^{*} (0.098)
W log(INCPC)	3.808^{***} (1.089)	1.545 (0.803)
WELEV	0.005 (0.008)	0.004 (0.006)
Spatial dependence and model fit		
ρ (spatial autoregressive)	0.350^{***}	0.335^{***}
LR test for $\rho = 0$ (p-value)	1.21×10^{-5}	2.92×10^{-5}
Wald test for $\rho = 0$ (p-value)	3.67×10^{-6}	1.25×10^{-5}
Log-likelihood	-514.760	-422.104
σ^2 (ML residual variance)	1.807	0.973
AIC (spatial model)	1047.50	862.21
AIC (OLS benchmark)	1064.70	877.68
LM test resid. autocorr. (p-val)	0.146	0.073
N	298	298
Impact decomposition (direct, indirect, total)		
Direct effects		
log(PDENS)	0.4905	0.1203
log(INCPC)	-1.8746	-0.0333
ELEV	0.0033	0.0017
Indirect effects		
log(PDENS)	-0.4071	-0.2443
log(INCPC)	4.4867	2.1431
ELEV	0.0094	0.0059
Total effects		
log(PDENS)	0.0835	-0.1240
log(INCPC)	2.6121	2.1098
ELEV	0.0127	0.0076

Table 1.8: Spatial Durbin Model estimates and impact decomposition (Metafrontier vs Gap ratio)

Figure 1.5 reports Local Getis-Ord Gi^* hot-spot and cold-spot clusters of fitted SDM values for both the meta-frontier and the gap-ratio outcomes at multiple significance thresholds. The emergence of contiguous hot- and cold-spot areas provides complementary, local-scale evidence of spatial structure in predicted liveability outcomes.

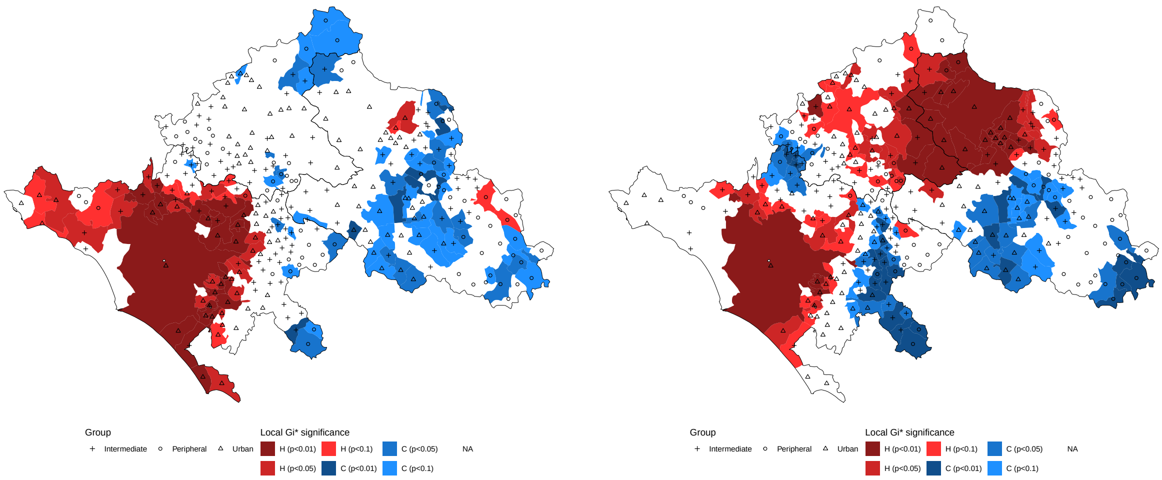


Figure 1.5: Local Getis–Ord G_i^* hot-spot and cold-spot clusters of the fitted values from SDM for Meta-frontier and Gap Ratio at different level of significance

1.4.2 Discussion

This subsection interprets the results with respect to the chapter's aim and research questions. The aim is to provide a context-sensitive assessment of liveability in Inner Areas, distinguishing absolute performance from structural disadvantage, and evaluating whether liveability efficiency is shaped by spatial interdependence and spillovers among neighbouring municipalities.

The meta-frontier and group-frontier distributions indicate that many municipalities are close to the efficient frontier, which is a typical feature of BoD/frontier-based measures. However, the gap ratio reveals that proximity to the frontier is not the whole story: some municipalities face a measurable distance between their group frontier and the global benchmark. This suggests that differences in liveability are not only about municipal performance, but also about the opportunity set associated with territorial context. In other words, the chapter's benchmarking strategy is instrumental to distinguish how municipalities perform from the constraints under which they perform.

Group comparisons show that differences depend on the metric. The absence of significant mean differences for the metafrontier score suggests that absolute performance relative to the global frontier does not vary sharply across BRANCH groups on average. By contrast, the gap ratio differs significantly, driven by Peripheral municipalities. This implies that the Peripheral condition is better characterized as a structural disadvantage in the benchmark environment (i.e., a larger distance between group frontier and meta-frontier) rather than as uniformly lower absolute efficiency. From a policy perspective, this distinction supports the rationale of place-based interventions: Peripheral municipalities may require measures that expand the feasible set of liveability outcomes (e.g., service networks, accessibility and institutional capacity), not only actions aimed at improving local efficiency.

The diagnostic evidence (Moran's I and LM tests) and the SDM results converge on the same conclusion: liveability efficiency is spatially structured. The significant and positive ρ indicates that municipalities' outcomes co-move with neighbouring outcomes, consistent with territorial spillovers and shared functional systems. The impact decomposition further clarifies that covariates operate through both within-municipality effects and cross-border context effects. Density tends to benefit the municipality directly while generating negative spillovers (or competitive/centralization dynamics) across neighbours, whereas income exhibits comparatively stronger positive indirect effects, suggesting that being embedded in a wealthier territorial environment can generate externalities that sustain liveability efficiency. The G_i^* maps reinforce these insights by showing spatially coherent clusters of predicted high and low outcomes, emphasizing that vulnerabilities and advantages are organized in territorial pockets rather than scattered randomly.

Overall, the chapter provides evidence that liveability in Inner Areas cannot be understood solely through aspatial municipal characteristics. The meta-frontier framework shows that structural disadvantages are more clearly captured by the gap ratio than by the meta-frontier score alone, while spatial econometric results demonstrate that both outcomes and their determinants are shaped by inter-municipal interactions. These findings imply that effective strategies aligned with SDG 11 and the SNAI rationale should be designed at the scale of territorial systems—service basins, clusters, and functional areas—in order to leverage positive spillovers and mitigate polarization mechanisms.

1.5 Final Remarks

This chapter contributes to the empirical assessment of Italian Inner Areas by combining an SDG11-aligned Liveability Composite Index (LCI) with a meta-frontier benchmarking strategy and a spatial econometric framework. Methodologically, the chapter advances beyond single-dimension interpretations of marginality by (i) operationalizing liveability as a multidimensional construct through BoD-based aggregation of Composite Indicators, (ii) separating absolute performance from structural disadvantage via meta-frontier analysis and the gap ratio, and (iii) explicitly modelling territorial interdependence through spatial diagnostics, Spatial Durbin estimation, impact decomposition, and local clustering analysis. Substantively, the results show that (a) average efficiency levels are generally high but conceal meaningful heterogeneity in the lower tail; (b) group differences emerge more clearly in the gap ratio than in the meta-frontier score, highlighting that the Peripheral condition is better understood as a disadvantage in the benchmark environment rather than as uniformly lower efficiency; and (c) liveability outcomes are spatially structured, with significant spillovers and coherent hot-spot/cold-spot patterns.

The findings also offer three main implications for place-based strategies such as SNAI and, more broadly, for Sustainable local development policies:

1. From municipalities to territorial systems. The presence of significant spatial dependence and the evidence of spillovers imply that interventions designed for isolated municipalities may be insufficient. Policies are likely to be more effective when implemented at the scale of functional territorial systems (e.g., service basins, inter-municipal networks, and clusters), where coordination can lever-

age positive externalities and reduce polarization dynamics.

2. Target structural disadvantage, not only local performance. The meta-frontier/gap-ratio results suggest that Peripheral areas may face constraints that limit the attainable liveability benchmark. This supports interventions aimed at expanding the feasible set—for instance by improving accessibility to essential services, strengthening institutional capacity, and enabling cooperative governance arrangements—in addition to measures aimed at improving within-municipality efficiency.

3. Use the index as a diagnostic and monitoring tool. The SDG 11-based Composite Indicators and the LCI can be used to identify which domains are systematically weaker and where they cluster spatially, supporting prioritization and monitoring. In practical terms, the combination of (i) domain-level indicators, (ii) benchmarking (MF/GF/GAP), and (iii) spatial hot-spot/cold-spot mapping provides a replicable framework to guide resource allocation, evaluate policy coherence, and track progress over time.

Overall, the chapter shows that a multidimensional measure of liveability, interpreted through a meta-frontier lens and embedded in a spatial framework, provides a more policy-relevant understanding of Inner Areas: it distinguishes performance from structural constraints and demonstrates that liveability is shaped by inter-municipal interactions. This reinforces the rationale for integrated, place-based interventions that operate across municipal boundaries and explicitly account for territorial spillovers.

Chapter 2

On the boundaries of conservation: the ecological impact of Protected Areas on landscape fragmentation

[1]

Abstract

Biodiversity loss and landscape fragmentation are among the most pressing environmental challenges, threatening ecosystem services and long-term ecological resilience. Protected Areas (PAs) represent a key policy instrument to counter these processes, yet their effectiveness is often questioned due to non-random site selection and data limitations. The impact of PAs on landscape fragmentation in three provinces of Central Italy is evaluated using a spatial Regression Discontinuity Design (RDD). CORINE Land Cover data for six years between 1990 and 2018 are employed, with Mesh Size Density ($MESH$) computed as the main fragmentation metric and PA boundaries exploited as quasi-experimental cutoffs. Results indicate consistent and statistically significant reductions in fragmentation inside PAs, with discontinuities of 15–18 MESH units, particularly pronounced in the early 2000s. Robustness checks — including McCrary density tests, placebo boundaries, and donut RDDs — confirm the validity of the design. While PAs are locally effective, broader conservation outcomes require stronger geographical and institutional connectivity among sites.

Keywords: *Protected Areas, Landscape Fragmentation, Human pressure, Regression Discontinuity, Buffer Areas*

[1] During the preparation of this work, the author used ChatGPT 5.2 in order to improve language. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

2.1 Introduction

The aim of this chapter is to evaluate whether Protected Areas reduce landscape fragmentation and by how much. It provides a quasi-experimental, boundary-based assessment that isolates the causal effect of protection at PA borders and reveals that benefits are concentrated mainly inside protected boundaries, thereby indicating that conservation policies should be complemented with connectivity measures (e.g., buffers and ecological corridors) to extend impacts beyond administrative limits.

The world's terrestrial biodiversity is declining at an unprecedented rate and urgent action is needed to protect intact landscapes, preserve biodiversity, and enhance sustainable use and restoration of ecosystems (IUCN, 2021). Conservation and recovery efforts must focus on protecting key areas essential for biodiversity through protected zones and other effective conservation measures. In addition, production landscapes should be redesigned and managed more effectively to ensure the protection of biodiversity and the vital services it supports. Given that approximately 75% of the global land surface has already been significantly altered by human activities (IUCN, 2021), the role of Protected Areas as key players in mitigating environmental degradation and maintaining ecological integrity has become even more crucial, as they are established in order to conserve biodiversity, sustain ecosystem functions and protect cultural heritage (Dudley et al., 2013). Protected Areas currently cover approximately 16. 64% of the global land and inland water ecosystems (Chen et al., 2023). While the coverage and recognition of PAs continue to grow, highlighting their essential role in ensuring a sustainable future for all life on Earth, further efforts are needed to enhance their effectiveness (Nyaupane et al., 2022). Strengthening conservation strategies, expanding protected zones, and integrating sustainable land and resource management practices are crucial to mitigating biodiversity loss and preserving vital ecosystem services.

The International Union for Conservation of Nature (IUCN) defines a Protected area as a clearly defined geographic space that is legally or effectively managed to ensure the long-term preservation of nature, along with its associated ecosystem services and cultural values (Dudley et al., 2013). To deal with the rapid decline of biodiversity and the degradation of landscapes, it is essential to expand and strengthen conservation efforts, integrating Protected Areas with broader sustainable land management strategies (Powlen et al., 2021). According to the IUCN, Protected Areas are classified into six categories with different management objectives:

1. Strict protection areas (*Strict Nature Reserves and Wilderness Areas*) aim to preserve ecological integrity with minimal human interference.

2. Ecosystem conservation and protection areas (*National Parks*) focus on maintaining natural processes and biodiversity while allowing some level of recreation.

3. Natural feature conservation areas (*Natural Monuments*) protect specific natural landmarks or unique geological formations.

4. Habitat/species management areas employ targeted conservation strategies to support specific species or ecosystems.

5. Landscape/seascape conservation and recreation areas (*Protected Landscapes/Seascapes*) balance conservation with human activities such as tourism and agriculture.
6. Sustainable resource use areas (*Resource Protected Areas*) integrate conservation with regulated human exploitation of natural resources.

One of the most pressing issues concerning PAs is their role in regulating land-use and land-cover change (Tesfaw et al., 2018). Protected Areas are often established to act as barriers against deforestation (Andam et al., 2008), urbanization (de Montis et al., 2017) and agricultural expansion (Demetriou et al., 2013) or to sustain the local livelihood (Naughton-Treves et al., 2005b). However, their effectiveness varies depending on governance structures, enforcement mechanisms, and external pressures (Anderson and Mammides, 2020). While some PAs have successfully slowed habitat loss (Powlen et al., 2021), others have faced significant challenges due to human expansion, weak institutional frameworks, and conflicting land-use priorities (Leroux and Kerr, 2013). Research has shown that legal and administrative changes in PA boundaries have been frequent, often influenced by economic and political pressures, which in turn impact the conservation effectiveness of these areas. Additionally, tourism growth has sometimes led to unintended consequences in PAs' surrounding zones, where increasing human presence and infrastructure development have triggered negative land-cover changes and habitat degradation (Bailey et al., 2016, Calderón et al., 2022, Nyaupane et al., 2022). This highlights the necessity for careful planning, participatory governance, and continuous monitoring to ensure that PAs function as effective tools for environmental protection while also addressing the needs of local communities.

In Italy, landscape conservation has long been a key component of environmental policies, reinforced by Framework Law 394/1991, which established a legal framework for Protected Areas and their management (Romano et al., 2021). This legislation played a key role in safeguarding Italy's ecologically and culturally significant landscapes. However, despite these protections, many Protected Areas have faced challenges in fully achieving their conservation objectives, particularly in economically disadvantaged regions where balancing environmental preservation with socio-economic development remains difficult (Sallustio et al., 2017). Early 20th-century legislation prioritized aesthetic values, emphasizing visual and artistic qualities, but modern approaches recognize landscapes as dynamic systems shaped by both natural and cultural processes (Saviano et al., 2018).

This evolving understanding of landscape conservation highlights the need for adaptive management approaches that integrate ecological, historical, and socio-economic dimensions. To better understand the challenges and effectiveness of Protected Areas in mitigating environmental degradation, the following section aims to explore key theoretical concepts, including anthropization, landscape fragmentation, and the role of PAs in preserving biodiversity and regulating land-use change. Thereafter - with a focus on the case study of three provinces in central Italy - the purpose of this paper is to provide an overview of the potential of Protected Areas to ensure ecological integrity in and beyond their boundaries and to cope with anthropogenic pressure.

2.2 Theoretical Background

Human activities are rapidly transforming ecosystems worldwide, often leading to landscape degradation and a significant decline in biodiversity (Anderson and Mammides, 2020, de Montis et al., 2017, Venter et al., 2016). This phenomenon is known as *anthropization* (Calderón et al., 2022), which has accelerated ecological risks by intensifying habitat destruction and land-cover changes, both of which disrupt ecological balance and degrade ecosystem functions (Sallustio et al., 2017). These changes not only lead to direct land loss but also introduce indirect effects, such as pollution, altered water cycles, and climaate instability (Marcantonio et al., 2013). Among the most significant consequences of anthropization is *landscape fragmentation*, which diminishes habitat connectivity, isolates species populations, and alters ecological dynamics (Lawrence et al., 2021).

Landscape is a complex and dynamic concept that encapsulates both natural and cultural dimensions. It represents the cumulative interactions between human societies and their environment over time, serving as a material record of cultural heritage and ecological evolution (Saviano et al., 2018). Landscapes provide essential ecosystem services, such as climate regulation, water filtration, and soil stability, while also holding aesthetic, historical, and recreational value (IUCN, 2021). However, human interventions have increasingly fragmented landscapes, disrupting their ecological integrity and leading to long-term environmental consequences.

Landscape fragmentation refers to the division of continuous natural habitats into smaller, isolated patches due to anthropogenic drivers such as urbanization, deforestation, agriculture, and infrastructure expansion (Gao and Li, 2011). Roads networks play a key role in landscape fragmentation by introducing physical barriers that restrict wildlife movement, increase mortality rates, and facilitate the spread of invasive species (Marcantonio et al., 2013). The expansion of road networks often leads to further human encroachment into natural areas, intensifying habitat degradation and land-use changes. Agricultural expansion is another driver of landscape fragmentation, as it converts large tracts of natural land into monoculture plantations or pasture lands (Demetriou et al., 2013). The replacement of diverse ecosystems with uniform agricultural fields reduces habitat heterogeneity, limits species diversity, and disrupts ecological processes. Urbanization also significantly contributes to landscape fragmentation by replacing natural landscapes with built environments, leading to land sealing, increased human disturbances, and habitat loss (di Giulio et al., 2009, Lourenço et al., 2015).

As urban populations grow, the pressure on surrounding landscapes intensifies, necessitating sustainable planning approaches to mitigate fragmentation and promote ecological restoration (Sims, 2014). The need for adaptive management approaches to landscape conservation is increasingly recognized in the face of rapid environmental changes. In this framework, Protected Areas cover a crucial role (Kubacka et al., 2022, Santiago-Ramos and Feria-Toribio, 2021) for conservation initiatives, to ensure long-term ecological and socio-economic benefits. Assessing landscape fragmentation is crucial for effective conservation planning and sustainable land-use management. Various quantitative and qualitative methods have been developed to evaluate fragmentation patterns and their ecological consequences (Llauss and Nogué, 2012). Landscape metrics such as patch size, edge length, splitting and fragmentation indices provide valuable insights into landscape structure and the extent of human-induced changes (Hargis et al., 1998, Jaeger, 2000). Geographic information systems (GIS), remote sensing technologies (Lam et al., 2018) and Land Cover databases (Hysa and Başkaya, 2017) enhance the chances to monitor and analyze fragmentation dynamics, enabling the identification of priority areas for conservation and ecological restoration.

To sum up, human expansion and anthropogenic pressure on the environment increasingly endanger natural landscape, causing along with its fragmentation other issues such as pollution, loss of biodiversity, and species isolation. Although Protected Areas can be a powerful tool for counteracting landscape fragmentation, several combined interventions are needed, starting with analysis on the territories where these are located and in surrounding zones, to assess possible beneficial effects that go beyond the boundaries of the established PAs. Thereafter, it would be necessary to return the analytical framework to policymakers and communities in order to develop interventions aimed at safeguarding the natural and cultural aspects of the landscape. From these assumptions, this paper aims to answer the questions: *how does the presence of Protected Areas impact different landscape fragmentation elements? And how does the distance from their boundaries impact it?* The purpose is to assess whether indeed Protected Areas succeed in fulfilling their preservation mandate and whether, possibly, this can be extended to surrounding zones as well. The present work also aims to provide a type of analysis approach distinct from those experienced in the literature, combining landscape metrics with the distance to Protected Areas and anthropic pressure elements at a fine resolution level, so as to obtain the sharpest possible results.

2.3 Methodology

2.3.1 Case study area and data collection

The chosen study area includes three provinces in central Italy: Rome, Rieti and L'Aquila. These three territories present diverse traits in several respects. On the one hand, the province of Rome is characterized by its namesake Metropolitan City, a large urban center and the capital of the Country. On the other, the territory that characterizes the other two provinces is mostly rural and mountainous, with small settlements frequently isolated from the main services.

For the present analysis, the entire area was divided into a grid dataset with 1 km^2 cells (Figure 2.1). This allows for a good level of detail when performing operations with data extracted from spatial datasets (Roy and Blaschke, 2014).

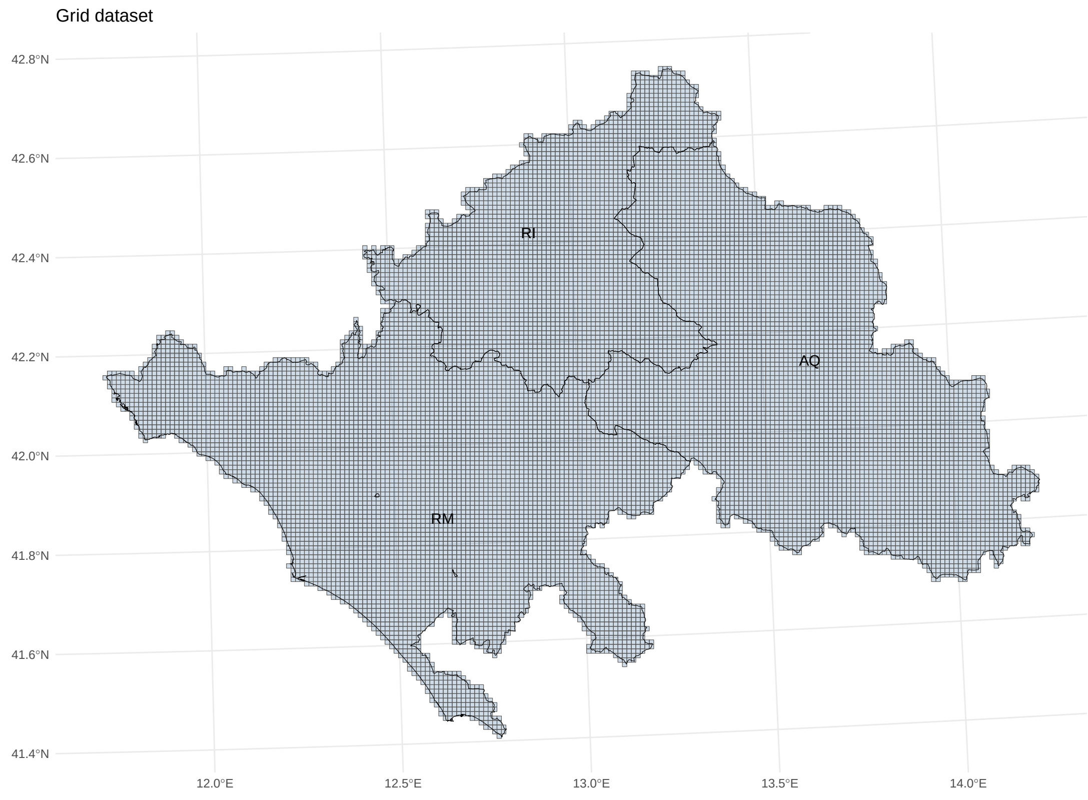


Figure 2.1: Cells grid on the Case Study Area. Source: own elaboration from ISTAT (2018)

Data on land use came from CORINE Land Cover (EEA, 2018). This is one of the most used databases when it comes with land use data elaboration, as it contains in a single image file a huge amount of informations on the nature of soil and anthropic changes. The dataset associates a code (from 100 to 500) with a different land use:

- 100: artificial areas (urban fabric, commercial and industrial zones...);
- 200: utilized agricultural areas (arable land, permanent crops, forage crops);

- 300: wooded areas and natural environments (wooded areas, natural areas with no vegetation);
- 400: wetlands (swamps, salt marshes);
- 500: water bodies (water basins, maritime areas).

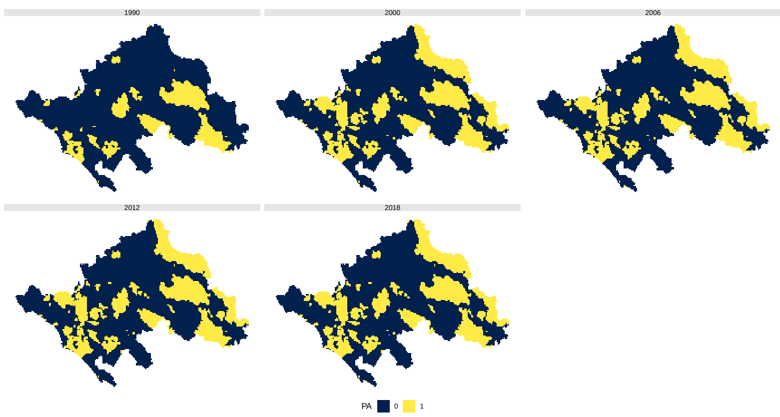
The analysis exploits six different time periods derived from the CORINE Land Cover dataset, which provides harmonized information on land-use and land-cover changes across the area. Using multiple years allows the study to capture temporal variation in fragmentation dynamics and to assess whether the effects of protected areas on landscape structure are consistent over time. Spatial data on the presence of PAs are collected from the World Database on Protected Areas (WDPA, 2024). Table 2.1 shows the general informations of PAs on the study area, namely the IUCN category, the designation and the total area. Table 2.2 allows to compare for each year the total area of PAs on the territory, while the Figure at the side shows their spatial distribution. For more insights on the Protected Areas, consult the Appendix A.

IUCN CATEGORY	**DESIGNATION**	**AREA (Hectares)**
II	National Park	267784.02
III	Other Protected Natural Regional Areas	1016.94
IV	Other Protected Natural Regional Areas	239.34
IV	Regional/Provincial Nature Park	103183.38
IV	Regional/Provincial Nature Reserve	14132.18
IV	State Nature Reserve	34382.41
Ia	State Nature Reserve	1529.35
Not Applicable	World Heritage Site (natural or mixed)	87074.19
Not Reported	Ramsar Site. Wetland of International Importance	675.78
V	Other Protected Natural Regional Areas	1211.98
V	Regional/Provincial Nature Park	45280.17
V	Regional/Provincial Nature Reserve	21957.19

Table 2.1: Protected Areas designation. Source: WDPA (2024)

year	**no pa** (km^2)	**pa** (km^2)
1990	11273	2356
2000	9246	4383
2006	9231	4398
2012	9216	4413
2018	9216	4413

Table 2.2: PA dimension. Source: WDPA (2024)



All the calculations were performed on R software with the following packages: *dplyr* for data management (Wickham et al., 2023), *sf* for the elaboration of shapefiles (Pebesma, 2018) and *terra* for raster files (Hijmans, 2025), *landscapemetrics* for the assessment of landscape fragmentation (Hesselbarth et al., 2019), and finally *rdrobust* for the computation of the RDD model (Calonico et al., 2025).

2.3.2 Landscape metrics and empirical model

In the case of this study, landscape is considered to be everything that has not been human-made. To assess the level of landscape fragmentation, *Mesh Size Density* ($MESH$) was computed for each cell. This landscape metric measures the number of patches per unit area, providing an estimate of fragmentation intensity. It is defined as:

$$MESH = \frac{1}{A}\sum_{i=1}^{n} A_i^2$$

where:

- A is the total landscape area,
- A_i is the area of the i-th patch,
- n is the total number of patches.

Assessing the effect of protected areas (PAs) on landscape fragmentation is challenging because protection is not randomly assigned: PAs are often established in less threatened or less accessible areas, which biases simple comparisons (Andam et al., 2008). A Regression Discontinuity Design (RDD) offers a suitable solution by exploiting the sharp boundary between protected and unprotected land. Assuming that unobserved factors vary smoothly across space, any discontinuity in fragmentation indicators at the boundary can be attributed to protection (Imbens and Lemieux, 2007, Lee and Lemieux, 2010). RDD has been widely applied in land-use and environmental economics precisely because many policies create such natural cutoffs (Wuepper and Finger, 2023). Empirical studies have shown its effectiveness in estimating conservation outcomes, for example in global forest protection (Neal, 2024) and farming practices at the East–West German border (Wuepper et al., 2020). In the Italian context, where high-resolution spatial data allow precise measurement of landscape metrics, RDD is especially well suited to identify local causal effects of PAs, thereby providing robust evidence for conservation policy.

Mesh Size Density (Figure 2.2) is a suitable dependent variable for the regression discontinuity design because it provides a robust and spatially explicit measure of landscape fragmentation. Unlike simple patch counts, MESH accounts for both the number and relative size of patches, thus capturing the structural integrity of landscapes in a way that is highly relevant for biodiversity and ecosystem functioning. Since protected areas are expected to reduce fragmentation by preserving larger, more contiguous habitat patches, discontinuities in MESH values at PA boundaries can be interpreted as credible evidence of conservation effectiveness. Moreover, the use of MESH has been well established in the landscape ecology literature as a sensitive indicator of anthropogenic pressures on land cover, making it a theoretically consistent and policy-relevant outcome variable for this analysis.

In this study, the treatment variable is defined as the distance from protected area borders ($DIST_PA$), with land just inside the boundary considered treated and land just outside considered control. This spatial running variable is well suited for a regression discontinuity design, since proximity to the boundary provides quasi-random variation in exposure to protection. However, to strengthen identification, it is important to account for covariates that systematically influence fragmentation irrespective of PA designation. Elevation ($ELEV$) is crucial because topography strongly shapes land-use intensity: higher altitudes are generally less favorable for agriculture or urban development, thus inherently associated with lower fragmentation pressure. Likewise, distance from major urban centers ($DIST$) captures accessibility and service proximity, both of which drive infrastructure expansion and land conversion. Controlling for these factors (Figure 2.3) ensures that the estimated discontinuity in fragmentation metrics at PA borders reflects the effect of protection, rather than underlying spatial heterogeneity in terrain or human pressure.

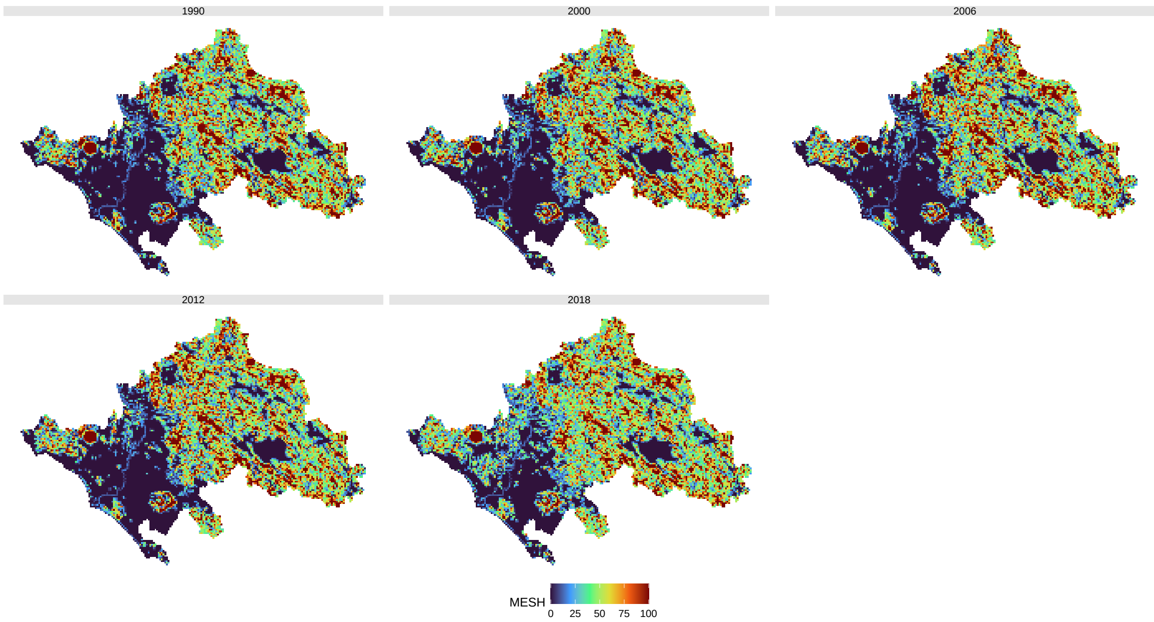


Figure 2.2: Spatial distribution of $MESH$ on cells. Source: own elaboration from EEA (2018)

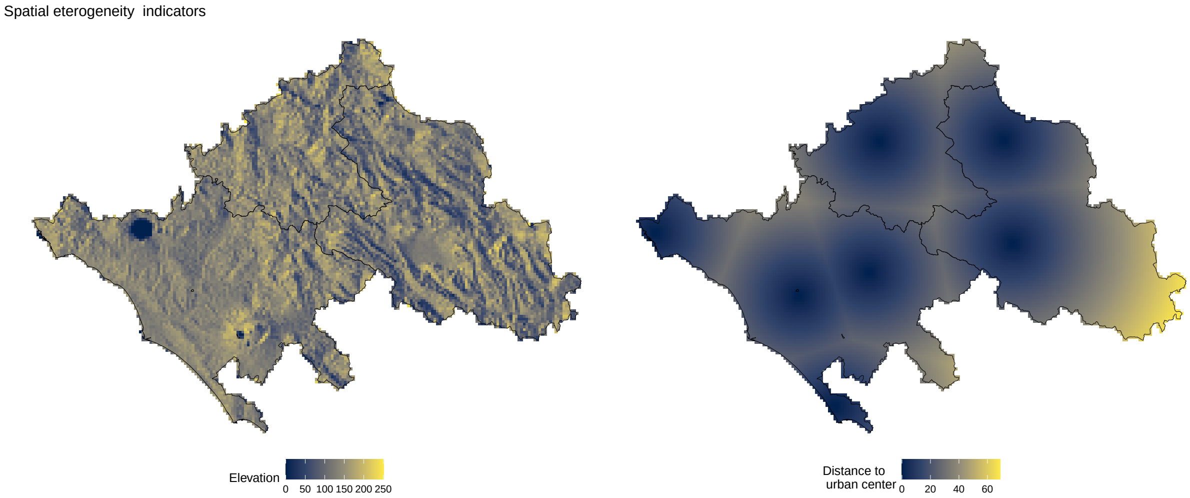


Figure 2.3: Spatial distribution of covariates. Source: own elaboration from ACT (2020), EUROSTAT (2018)

The empirical model results as:

$$Y_i = \alpha + \tau D_i + \mathbf{X}_i' \gamma + \varepsilon_i, \quad |s_i| \leq h$$

Where:

- Y_i: outcome variable, measured as *Mesh Size Density (MESH)* for grid cell i.
- α: intercept, capturing the baseline level of fragmentation at the boundary.
- D_i: treatment indicator equal to 1 if the cell lies inside the protected area (PA) and 0 if outside.
- τ: coefficient of interest, measuring the *causal effect of protection* as the discontinuity in Y at the PA boundary.
- $\mathbf{X}_i$: vector of covariates that influence fragmentation independently of PA status, such as *elevation (ELEV)* and *distance to major urban centers (DIST)*.
- γ: coefficients on the covariates.
- ε_i: error term.
- $|s_i| \leq h$: restriction to observations within a chosen *bandwidth* h around the PA boundary, ensuring a valid local comparison between treated and control cells.

For each year, we run regressions using alternative bandwidth choices of $h = 3000$, 5000, and 8000 meters around the PA boundary. This strategy allows us to examine the robustness of the estimated treatment effects across time and spatial scales, before turning to the main results.

2.4 Results and Discussion

The regression discontinuity analysis shows a consistent and robust protective effect of PAs on landscape fragmentation. Table 2.3 presents the regression discontinuity design estimates of the main treatment effect and associated covariates across years (1990, 2000, 2006, 2012, 2018) with a 5 km buffer. The structure of the table is organized into three panels: (i) the running variable $DIST\_PA$ (distance to protected area), which captures the main treatment effect (τ), (ii) $DIST$, which controls for additional spatial variation, and (iii) $ELEV$ (elevation), another covariate that could confound the estimates if not balanced at the cutoff. For each parameter, the table reports point estimates, standard errors (se), confidence intervals (CI low and CI high), and p-values (pv). The estimated coefficients (τ) are consistently negative across all years, ranging between approximately -10.6 (1990) and -18.3 (2018). These results suggest that being just inside the protected area boundary is associated with significantly lower outcomes of the dependent variable. The magnitudes are large and remarkably stable over time, with most estimates lying between -15 and -18. All of these effects are highly statistically significant ($pv = 0.000$), and the confidence intervals exclude zero in every year. This consistency reinforces the credibility of the treatment effect and indicates a persistent discontinuity across decades. However, at the same level of buffer, it can be observed that the jump remain constant across years. For the covariate $DIST$, the estimated discontinuities (γ_1) are extremely small (around 0.6–0.7) and not statistically significant (p-values consistently above 0.6). Confidence intervals also include zero throughout. This strongly suggests that distance-related characteristics are balanced across the cutoff, supporting the validity of the identification strategy. For the covariate $ELEV$, the estimated discontinuities (γ_2) are similarly small (around -0.004 to -0.010) and statistically insignificant at conventional levels (p-values $\approx$ 0.2–0.9). These results imply that elevation does not systematically differ across the cutoff, ruling out the possibility that terrain variation is driving the main results. The table highlights two key findings. First, the treatment effect of proximity to protected areas is robust, negative, and persistent across years, suggesting that protected status generates clear discontinuities in outcomes. Second, the absence of significant jumps in covariates (DIST and ELEV) confirms that the observed discontinuities are not due to imbalances in spatial or geographic characteristics, but instead reflect a genuine treatment effect. From a methodological perspective, this table strengthens the internal validity of the RDD design by demonstrating both strong and consistent treatment effects and credible covariate balance. From a substantive perspective, the results indicate that the presence of protected areas leads to durable reductions in the outcome of interest (likely related to human pressure or land conversion), with little evidence that this relationship is confounded by geography or spatial distribution.

Figure 2.4 provides graphical evidence of the discontinuities in $MESH$ Size Density ($MESH$) at PA borders across years and bandwidths. In all panels, the fitted regression lines clearly diverge at the cutoff, with lower values inside PAs (to the right of the vertical line) compared to outside (to the left). This visual pattern reinforces the numerical estimates in Table 3 and confirms that the reduction in fragmentation is concentrated at PA boundaries. For the 3 km bandwidth, the discontinuities are sharp and clearly visible in every year. The regression lines drop abruptly at the boundary, with a particularly pronounced gap in 2000, 2006, and 2012, when the fitted values inside PAs are about 15–20 points lower than those just outside. These strong local effects align with the statistically significant coefficients reported in the regressions. At the 5 km bandwidth, the discontinuities remain visible but are less pronounced. The regression lines on both sides of the cutoff are flatter, and the vertical gap shrinks to around 8–12 points depending on the year. This suggests that the protective effect of PAs is strongest immediately at the boundary and attenuates with distance, as expected. For the 8 km bandwidth, the fitted lines are smoother and the discontinuities are barely visible in some years, such as 1990 and 2018. This is consistent with the lower magnitude and reduced significance of the coefficients in Table 3. The attenuation reflects the inclusion of cells farther from the boundary, where the RDD identification assumption weakens and ecological pressures are more heterogeneous.

		Running Variable (DIST_PA)					DIST					ELEV				
year	**buffer (km)**	τ	**se**	**pv**	**CI low**	**CI high**	γ_1	**se**	**pv**	**CI low**	**CI high**	γ_2	**se**	**pv**	**CI low**	**CI high**
	3	-10.612	3.230	0.001	-23.501	-16.943	0.766	0.049	0.000	0.703	0.898	-0.072	0.016	0.000	-0.108	-0.044
1990	5	-15.863	2.814	0.000	-18.272	-21.378	0.656	0.044	0.000	0.609	0.782	-0.048	0.015	0.001	-0.079	-0.020
	8	-16.066	2.884	0.000	-19.946	-21.718	0.578	0.041	0.000	0.531	0.691	-0.050	0.015	0.001	-0.077	-0.020
	3	-15.933	2.691	0.000	-30.704	-21.207	0.598	0.038	0.000	0.557	0.705	-0.071	0.013	0.000	-0.095	-0.044
2000	5	-15.564	2.440	0.000	-28.842	-20.346	0.620	0.036	0.000	0.584	0.726	-0.068	0.012	0.000	-0.091	-0.043
	8	-17.191	2.587	0.000	-27.267	-22.262	0.564	0.037	0.000	0.531	0.676	-0.065	0.013	0.000	-0.089	-0.040
	3	-17.535	2.695	0.000	-26.953	-22.818	0.643	0.038	0.000	0.600	0.749	-0.079	0.013	0.000	-0.103	-0.052
2006	5	-17.189	2.490	0.000	-28.610	-22.069	0.564	0.037	0.000	0.529	0.673	-0.058	0.012	0.000	-0.083	-0.034
	8	-16.581	2.599	0.000	-30.951	-21.674	0.543	0.038	0.000	0.512	0.660	-0.052	0.013	0.000	-0.076	-0.027
	3	-18.161	2.653	0.000	-27.266	-23.361	0.637	0.037	0.000	0.593	0.738	-0.058	0.013	0.000	-0.083	-0.033
2012	5	-20.064	2.481	0.000	-28.914	-24.928	0.610	0.036	0.000	0.583	0.725	-0.074	0.012	0.000	-0.099	-0.050
	8	-15.687	2.550	0.000	-29.212	-20.685	0.574	0.038	0.000	0.536	0.686	-0.071	0.013	0.000	-0.094	-0.045
	3	-15.126	2.554	0.000	-27.770	-20.131	0.532	0.035	0.000	0.492	0.630	-0.071	0.012	0.000	-0.093	-0.046
2018	5	-14.213	2.421	0.000	-25.478	-18.958	0.514	0.034	0.000	0.479	0.612	-0.072	0.012	0.000	-0.095	-0.049
	8	-13.888	2.472	0.000	-26.551	-18.732	0.497	0.036	0.000	0.455	0.597	-0.073	0.012	0.000	-0.097	-0.049

Table 2.3: RDD results and covariates

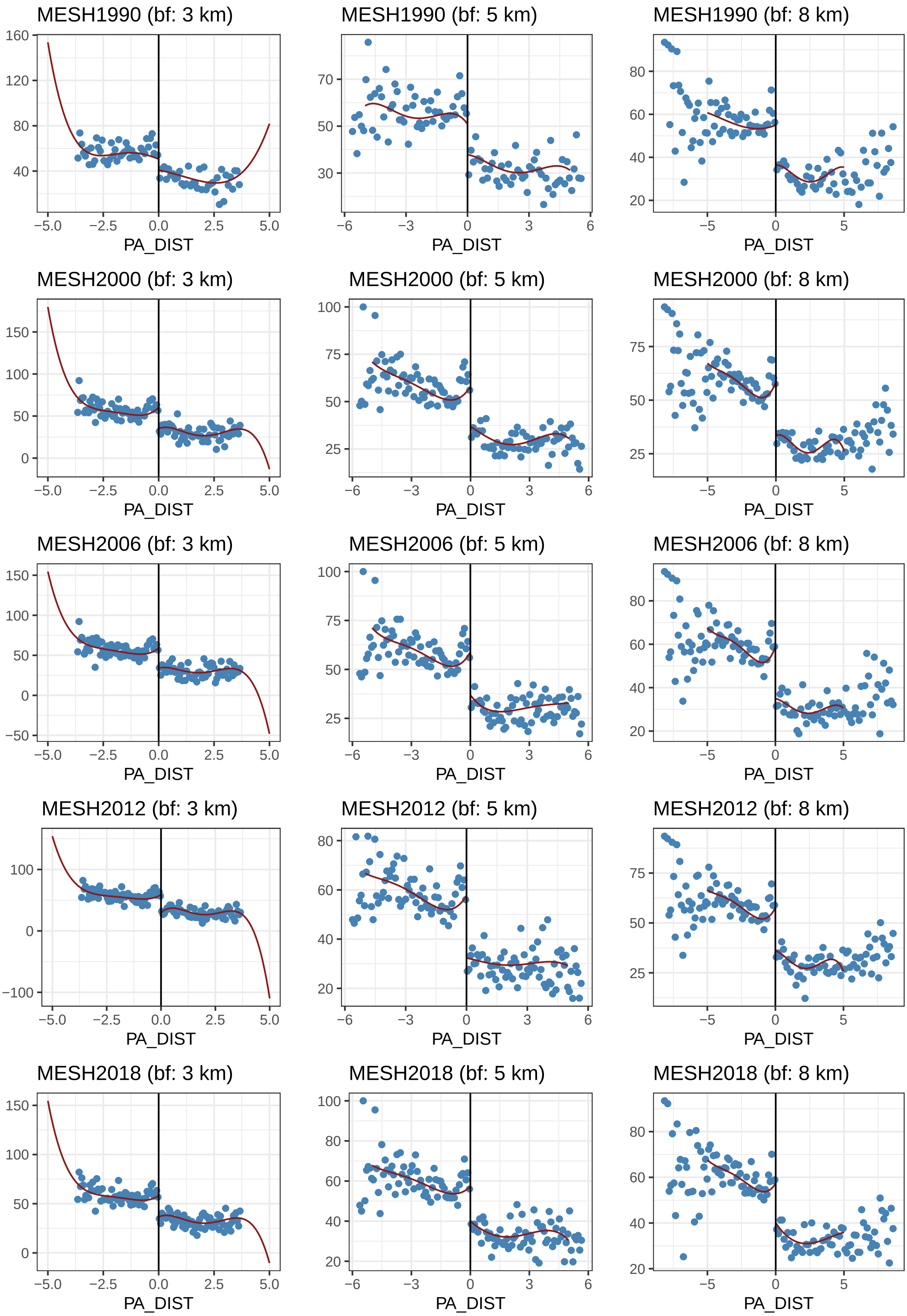


Figure 2.4: RD results

A crucial validity check for the regression discontinuity design is the continuity of the running variable at the cutoff. If land cells were systematically sorted just inside or outside protected area boundaries, the identifying assumption of the RDD would be compromised (McCrary, 2008). To test for such manipulation, we implement the McCrary density test using the signed distance to PA borders as the running variable. Table 2.4 and Figure 2.5 presents the McCrary density test results for different years (1990, 2000, 2006, 2012, and 2018) across buffer distances of 3 km, 5 km, and 8 km. The test is designed to detect discontinuities in the density of observations around a threshold, where significant jumps may indicate manipulation or sorting behavior. The estimates of the density on the left ($\hat{f}_-$) and right ($\hat{f}_+$) of the cutoff are reported alongside their difference ($\Delta \hat{f}$), the sample sizes (N_-, N_+), and the corresponding p-values (pv). A clear pattern emerges at the smallest buffer size (3 km), where the estimated discontinuity ($\Delta \hat{f}$) is large and statistically significant across all years, with p-values equal to 0.000. For instance, in 1990 and 2000 the density on the right-hand side of the cutoff ($\hat{f}_+$) is nearly twice as large as on the left, leading to sharp discontinuities of 0.149 and 0.137, respectively. This consistent evidence suggests strong manipulation or sorting behavior immediately around the cutoff. When the buffer widens to 5 km, the estimated discontinuities are much smaller, typically between 0.007 and 0.019, and their significance largely disappears, with p-values ranging from 0.282 to 0.650. This indicates that once a slightly broader window is considered, the sharp differences at the cutoff lose importance, weakening the case for systematic manipulation at this scale. At the widest buffer of 8 km, the estimated discontinuities ($\Delta \hat{f}$) are mostly negative, suggesting slightly lower densities to the right of the cutoff, though magnitudes remain small (-0.011 to -0.039). In most cases, the p-values are above standard significance thresholds, such as 0.482 in 1990 and 0.213 in 2000, further supporting the absence of discontinuities at larger distances. The main exception is 2012, where the test yields a negative but statistically significant discontinuity ($\Delta \hat{f} = -0.039$, $pv = 0.005$), implying some localized irregularity in that year. Overall, the results suggest that potential manipulation or sorting behavior, if it exists, is concentrated very close to the cutoff (within 3 km) and diminishes quickly as the buffer widens. The robustness of the 3 km findings across all years highlights a persistent and localized pattern, whereas the lack of significance at 5 km and 8 km buffers suggests that the discontinuities do not generalize to broader areas. This indicates that strategic responses are highly localized and unlikely to reflect systematic manipulation at larger spatial scales.

year	**buffer (km)**	$\hat{f}_-$	$\hat{f}_+$	$\Delta\hat{f}$	N_-	N_+	**pv**
1990	3	0.162	0.311	0.149	1196	1196	0.000
	5	0.199	0.218	0.019	1499	1449	*0.282*
	8	0.192	0.181	-0.011	1742	1484	*0.482*
2000	3	0.170	0.307	0.137	1952	1952	0.000
	5	0.204	0.212	0.008	2196	2107	*0.597*
	8	0.196	0.178	-0.018	2204	1823	*0.213*
2006	3	0.170	0.311	0.141	1952	1952	0.000
	5	0.204	0.211	0.007	2196	2132	*0.642*
	8	0.196	0.172	-0.024	2204	1821	*0.089*
2012	3	0.169	0.299	0.130	1979	1979	0.000
	5	0.204	0.218	0.014	2207	2111	*0.341*
	8	0.196	0.157	-0.039	2204	1831	*0.005*
2018	3	0.169	0.300	0.131	1979	1979	0.000
	5	0.204	0.211	0.007	2207	2109	*0.650*
	8	0.196	0.176	-0.020	2204	1813	*0.161*

Table 2.4: McCrary density test

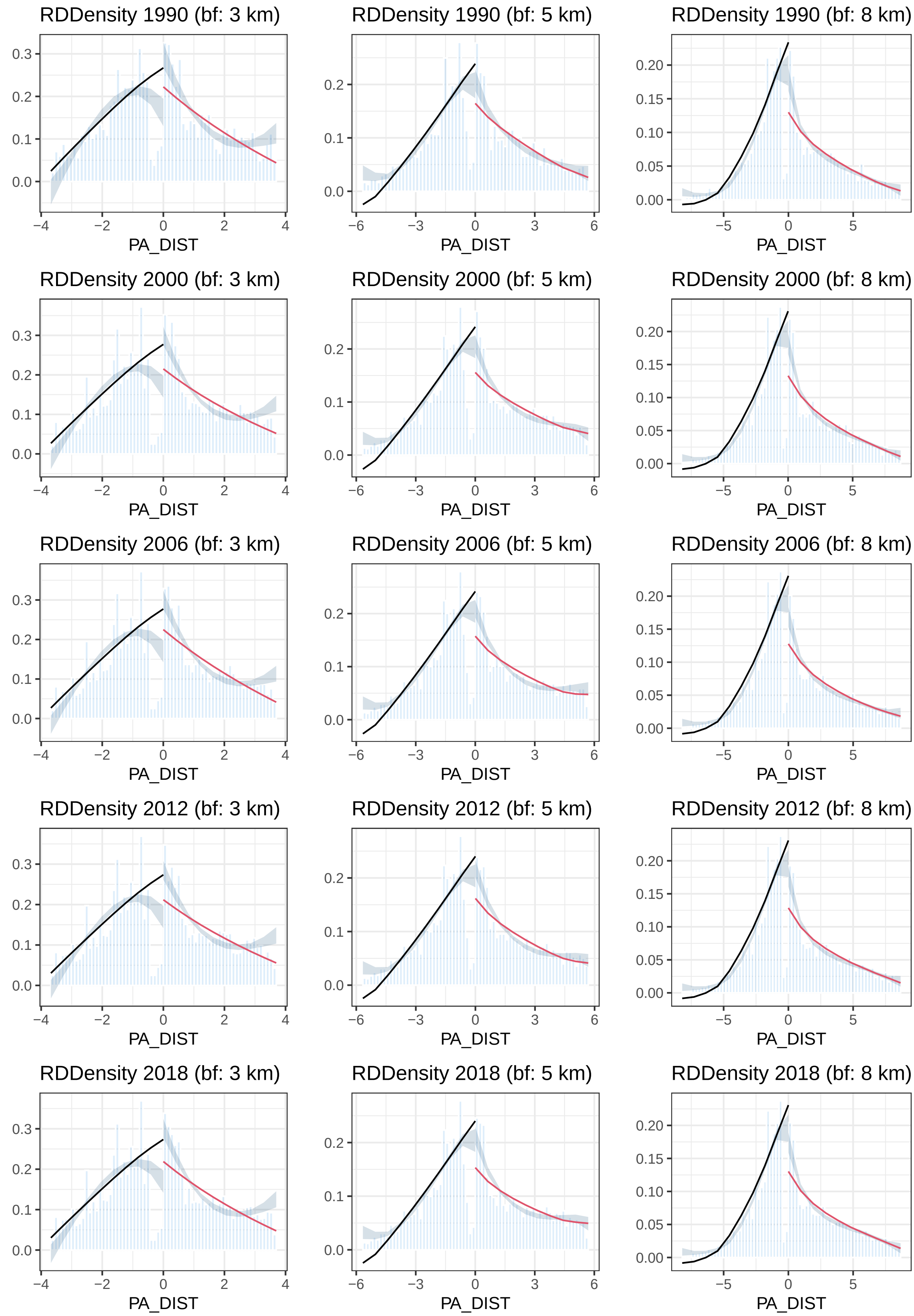


Figure 2.5: RDDensity plot

As an additional robustness check, a set of placebo RDDs is conducted, using artificial cutoffs located at arbitrary distances from the true PA borders. The rationale is straightforward: if the estimated discontinuities in $MESH$ were spurious or driven by broader spatial trends unrelated to protection, we would expect to observe similarly large and significant effects at these placebo thresholds. By contrast, if the causal effect is genuine, the estimates at fake cutoffs should be close to zero and statistically insignificant (Imbens and Lemieux, 2007). Table 2.5 reports the results of the placebo tests across different years (1990, 2000, 2006, 2012, and 2018) and buffer sizes of 3 km, 5 km, and 8 km. The placebo test is intended to verify whether the estimated treatment effects (τ) could be driven by spurious correlations or random variation rather than a true discontinuity. The table presents the estimated treatment effect (τ), the corresponding placebo-adjusted estimate (placebo-τ), the standard error (se), and the proportion of placebo replications that were significant (sign. prop.). Across all years and buffer sizes, the estimated treatment effects (τ) are consistently negative, ranging between approximately -10.6 and -20.1. This indicates that the main estimates point towards a negative effect around the cutoff. Importantly, the placebo-adjusted estimates are relatively small in magnitude, typically lying between -0.309 and 1.542, which suggests that placebo replications do not generate strong artificial discontinuities. The reported standard errors (se) range from around 4.8 to 8.8, implying moderate variability in the placebo distribution, with wider confidence intervals at smaller buffers. The proportion of significant placebo estimates is generally low, with most values between 0.25 and 0.50. This is consistent with what one would expect under the null of no manipulation, as approximately 5–10% significance rates would be expected by chance, but the reported values indicate no systematic bias in placebo results across years and buffers. Taken together, the findings suggest that the observed treatment effects are unlikely to be artifacts of random variation or specification choices. The placebo-τ values are small and unstable across specifications, while the relatively modest significance proportions reinforce the credibility of the main results. This strengthens the interpretation that the estimated discontinuities in the main analysis are genuine and not driven by spurious factors.

As a final step to further verify the robustness of the findings, we estimate a series of donut RDDs in which grid cells located within a narrow buffer zone around the PA boundary are excluded from the analysis. This procedure addresses potential concerns that measurement error, boundary misclassifications, or edge effects may artificially drive the observed discontinuities in $MESH$. Table 2.6 reports the results of the donut-hole tests, which evaluate the robustness of the RDD estimates by systematically excluding observations in narrow windows around the cutoff (5%, 10%, and 25%). Across all years and buffer sizes, the results are remarkably consistent with the baseline estimates. The treatment effects remain large, negative, and highly statistically significant, with magnitudes generally between -13 and -20, closely mirroring the original findings. As the excluded window around the cutoff widens, the estimates show only minimal variation and retain their significance, suggesting that the discontinuities are not an artifact of data points immediately adjacent to the boundary. The standard errors remain relatively stable, and the p-values are uniformly equal to 0.000, reinforcing the robustness of the results. These findings provide strong reassurance that the observed discontinuities in the RDD analysis are genuine and not driven by local anomalies near the cutoff. From a methodological perspective, the donut tests add credibility to the identification strategy by showing that the main conclusions hold even when potentially problematic observations are removed. Substantively, this further strengthens the interpretation that protected area boundaries consistently generate significant and durable effects, and that these effects are not sensitive to local noise but instead reflect a robust underlying pattern.

year	**buffer (km)**	τ	**placebo-**τ	**se**	**sign. prop.**
1990	3	-10.612	1.331	8.848	0.375
	5	-15.863	1.376	6.513	0.5
	8	-16.066	1.253	5.963	0.5
2000	3	-15.933	0.173	6.261	0.5
	5	-15.564	0.482	4.824	0.5
	8	-17.191	1.542	5.866	0.25
2006	3	-17.535	-0.299	5.885	0.375
	5	-17.189	0.623	4.941	0.5
	8	-16.581	1.287	6.024	0.25
2012	3	-18.161	-0.309	6.568	0.5
	5	-20.064	0.908	5.442	0.5
	8	-15.687	1.193	6.183	0.25
2018	3	-15.126	-0.029	6.091	0.375
	5	-14.213	0.713	4.919	0.5
	8	-13.888	1.207	6.200	0.25

Table 2.5: Placebo test results

			5%						10%						25%					
year	**buffer**	τ	**gap width**	**donut-τ**	**se**	**pv**	**CI low**	**CI high**	**gap width**	**donut-τ**	**se**	**pv**	**CI low**	**CI high**	**gap width**	**donut-τ**	**se**	**pv**	**CI low**	**CI high**
	3	-10.612	0.090	-15.019	1.956	0.000	-18.853	-11.185	0.195	-15.598	2.072	0.000	-19.658	-11.538	0.507	-18.144	2.503	0.000	-23.049	-13.239
1990	5	-15.863	0.115	-16.426	1.774	0.000	-19.903	-12.949	0.244	-17.026	1.895	0.000	-20.740	-13.313	0.675	-22.082	2.373	0.000	-26.733	-17.430
	8	-16.066	0.136	-15.341	1.659	0.000	-18.594	-12.089	0.294	-15.476	1.762	0.000	-18.931	-12.022	0.807	-19.239	2.429	0.000	-23.999	-14.478
	3	-15.933	0.089	-13.460	1.623	0.000	-16.642	-10.279	0.197	-13.344	1.705	0.000	-16.686	-10.001	0.517	-13.672	2.069	0.000	-17.727	-9.616
2000	5	-15.564	0.115	-13.752	1.500	0.000	-16.693	-10.811	0.254	-13.568	1.583	0.000	-16.671	-10.466	0.691	-15.609	2.026	0.000	-19.581	-11.638
	8	-17.191	0.139	-14.210	1.507	0.000	-17.163	-11.257	0.299	-14.131	1.604	0.000	-17.275	-10.986	0.826	-15.839	2.290	0.000	-20.329	-11.350
	3	-17.535	0.091	-13.164	1.636	0.000	-16.371	-9.957	0.200	-13.110	1.718	0.000	-16.478	-9.743	0.524	-13.759	2.083	0.000	-17.843	-9.676
2006	5	-17.189	0.118	-13.681	1.508	0.000	-16.637	-10.726	0.256	-13.681	1.591	0.000	-16.800	-10.561	0.705	-16.125	2.029	0.000	-20.102	-12.148
	8	-16.581	0.140	-14.053	1.515	0.000	-17.023	-11.083	0.302	-14.240	1.610	0.000	-17.397	-11.084	0.835	-16.921	2.321	0.000	-21.470	-12.372
	3	-18.161	0.091	-14.636	1.621	0.000	-17.813	-11.459	0.202	-14.763	1.702	0.000	-18.100	-11.426	0.531	-16.240	2.071	0.000	-20.300	-12.181
2012	5	-20.064	0.119	-14.931	1.501	0.000	-17.872	-11.989	0.260	-15.109	1.585	0.000	-18.215	-12.003	0.706	-18.269	2.073	0.000	-22.333	-14.206
	8	-15.687	0.140	-14.974	1.513	0.000	-17.939	-12.009	0.305	-15.240	1.607	0.000	-18.389	-12.091	0.843	-18.562	2.343	0.000	-23.155	-13.969
	3	-15.126	0.091	-13.013	1.539	0.000	-16.029	-9.997	0.202	-13.129	1.617	0.000	-16.298	-9.961	0.531	-14.532	1.941	0.000	-18.336	-10.727
2018	5	-14.213	0.119	-13.543	1.423	0.000	-16.332	-10.754	0.260	-13.491	1.501	0.000	-16.433	-10.549	0.706	-17.368	1.931	0.000	-21.153	-13.583
	8	-13.888	0.140	-13.655	1.433	0.000	-16.464	-10.845	0.305	-13.900	1.518	0.000	-16.874	-10.925	0.843	-17.754	2.165	0.000	-21.998	-13.510

Table 2.6: Donut test results

2.5 Final Remarks

The findings of this study demonstrate that Protected Areas (PAs) in the study territory consistently reduce landscape fragmentation. Across six CORINE periods spanning nearly three decades, the discontinuity in $MESH$ Size Density ($MESH$) remains large, negative, and statistically significant. This persistence highlights the long-term effectiveness of PAs in preserving contiguous habitat patches despite ongoing anthropic pressures. The magnitude of the discontinuity is remarkably stable over time: while the protective effect is robust, it does not appear to diminish or expand substantially across years.

From a policy perspective, this stability conveys a dual message. On the one hand, it confirms that PAs are fulfilling their conservation mandate by providing a reliable barrier against fragmentation. On the other hand, the fact that the "jump" at PA borders remains constant also suggests that protection is largely confined to within the boundaries themselves. Fragmentation pressures just outside remain high, and no evidence emerges of spillover benefits into adjacent landscapes. This finding points to a need for improved geographical and institutional connectivity among PAs. Strengthening ecological corridors, buffer zones, and cross-boundary governance could extend the benefits of protection beyond individual sites, fostering a broader and more resilient conservation network. In practice, this means prioritizing landscape-scale strategies that integrate PAs into wider land-use planning frameworks, ensuring that ecological processes and species movements are not disrupted at administrative boundaries.

While the study provides robust evidence of the effectiveness of protected areas in reducing fragmentation at their borders, several limitations should be acknowledged. First, the regression discontinuity design identifies local treatment effects at PA boundaries; by construction, the results cannot be generalized to the entire area within PAs or to landscapes located far outside. This raises the issue of external validity, as the causal effects estimated here are highly local and may differ from broader regional or national patterns. Second, the analysis is limited by the use of $MESH$ Size Density as the sole fragmentation indicator. While this is a widely accepted and robust measure, it does not capture all aspects of ecological quality, such as species richness, habitat heterogeneity, or ecosystem services. Consequently, the study may understate or overlook complementary ecological benefits of protection.

These limitations also open promising avenues for future research. First, further work could expand the analysis to alternative landscape metrics (e.g., Shannon's diversity index, effective $MESH$ size, or connectivity indices) to provide a more comprehensive assessment of ecological outcomes. Second, combining fragmentation metrics with biodiversity or ecosystem service data would allow evaluation of whether the observed reduction in fragmentation translates into tangible conservation benefits. Third, a valuable development would be to analyze institutional and geographical connectivity among PAs, investigating how ecological corridors or buffer zones can amplify the protective effect beyond the strict boundaries of protected sites.

Overall, the study provides robust empirical evidence that PAs are effective in protecting the land directly within their borders, but also highlights the importance of policy efforts aimed at linking these areas together. By moving from isolated units toward a connected system of conservation, could be possible to transform the consistent local success of PAs into a broader strategy for ecological protection.

Chapter 3

Beyond the Environmental Quest: Protected Areas as Social-Ecological Systems

[1]

Abstract

Protected Areas (PAs) are increasingly recognized as systems where biodiversity conservation, governance, and community well-being intersect. This paper investigates how PAs engage local actors and connect across territorial boundaries, focusing on seven case studies along the Cammino Naturale dei Parchi (CNP) in central Italy. An integrated analytical framework, combining Ostrom's Social-Ecological Systems model with the IUCN WCPA evaluation criteria, was developed to assess governance capacity, ecological effectiveness, and inclusiveness. Semi-structured interviews with park representatives reveal significant variation: peri-urban parks display strong participation but face intense anthropogenic pressures, while mountain reserves suffer from depopulation and limited institutional capacity. Across contexts, staff shortages and resource constraints remain persistent challenges, yet partnerships with municipalities, associations, and volunteers enable innovative practices. The CNP emerges as a connective infrastructure that fosters collaboration and shared identity. Overall, the study highlights the value of an SES perspective in analyzing PAs as dynamic nodes of ecological resilience, governance, and community vitality.

Keywords: *Protected Areas, Inclusive Governance, Socio-Ecological Systems, Hiking Trails*

[1] During the preparation of this work, the author used ChatGPT 5.2 in order to improve language. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

3.1 Introduction

The aim of this chapter is to understand Protected Areas as social–ecological systems by examining how governance arrangements shape participation and management outcomes. It provides a comparative institutional analysis of different administrative models, showing how polycentric and shared governance can strengthen collective action while reducing distance and enforcement costs, thereby offering actionable guidance for designing more legitimate and effective conservation institutions.

Protected Areas (PAs) play a crucial role worldwide in biodiversity conservation strategies, serving as primary defense against deforestation, habitat loss, and species extinction (Joppa et al., 2008). Their protective function is not only linked to the protection of biodiversity, but also to the maintenance of fundamental ecosystem services such as water and food supply or carbon storage (Hockings, 2003). In recent decades, the mission of Protected Areas has expanded beyond ecological conservation. International frameworks emphasize their role in promoting human well-being, linking conservation to development and poverty reduction (Naughton-Treves et al., 2005a). The ability to provide ecosystem services also plays a key role in supporting local livelihoods (Schirpke et al., 2021). Increasingly, PAs are seen as socio-ecological landscapes where cultural heritage, tourism, and livelihoods are entangled with ecological protection. For this reason, the social and human dimension is a fundamental part of their nature, and in this context, the inclusion of resident communities is essential. Despite this vision, community inclusion remains a persistent challenge. Local perceptions of Protected Areas are highly context-dependent, with some cases showing that most residents around them report positive impacts on their livelihoods, while in others communities express much more negative views, differences that can be largely explained by governance structures and inclusiveness (Abukari and Mwalyosi, 2020). A key role is played by attachment to place, that further mediates how communities engage with conservation: when residents identify strongly with a neighboring park, they are more likely to adopt pro-environmental civic behaviors and participate in management. Conversely, exclusionary governance weakens attachment and cooperation (Buta et al., 2014). Evidence consistently demonstrates that participation is decisive for successful compliance. A meta-analysis of PAs in developing countries found that community involvement in decision-making was the single strongest predictor of adherence to conservation rules, outweighing ecological, geographic, and economic variables (Andrade and Rhodes, 2012). However, in practice, participation often remains symbolic, and there may be cases where consultation processes are illusory, due to weak communication and limited influence on actual management (Grönholm, 2009). Despite their mandate, Protected Areas differ globally in their effectiveness, depending largely on management capacity and governance arrangements. Many Pas face chronic underfunding, weak institutional support, and limited staff capacity, all of which compromise their ability to achieve conservation objectives (Hockings et al., 2004). An example of this is "paper parks" — sites that exist only on maps with little or no application in the field — a phenomenon that exists particularly in developing countries, where management systems are often under-resourced and lack accountability (Cook et al., 2014).

Assessments of management effectiveness have proliferated as tools for addressing these concerns, such as the IUCN World Commission on Protected Areas frameworks (figure 3.1), which emphasize planning, inputs, processes, outputs, and outcomes as interdependent elements of success (Hockings et al., 2006).

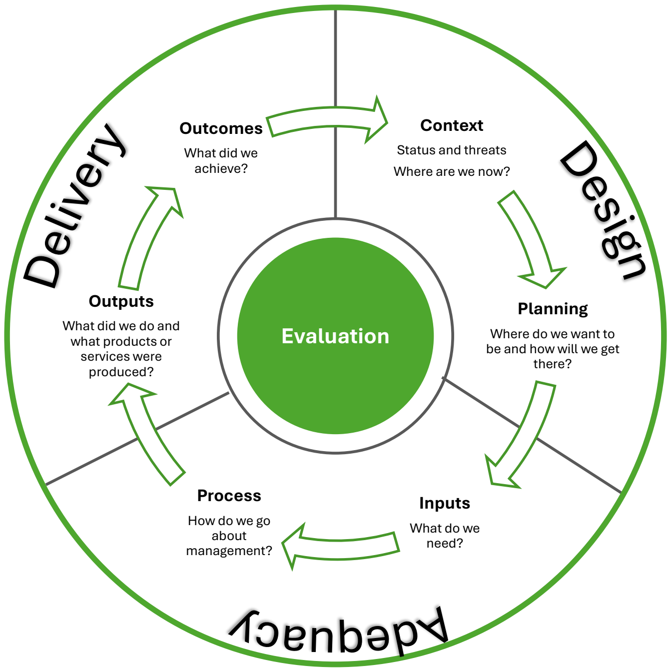


Figure 3.1: The Framework for assessing management effectiveness of Protected Areas. Source: Hockings et al. (2006)

Overall, governance models often remain centralized, limiting the involvement of local actors and reducing opportunities for adaptive, context-specific management.

Building on these assumptions, the paper explores aspects that concern the management of Protected Areas and their inclusiveness of other local actors in their activities, in order to understand their capability of being not only an institutional bodies, but proper systems that imply several streams of common goals and interactions.

3.2 Theoretical Background

Governance has emerged as a central determinant of the effectiveness and legitimacy of Protected Areas. Beyond ecological protection, governance frameworks highlight principles of transparency, accountability, participation, and equity, which influence both conservation outcomes and social acceptance (Eagles et al., 2013). Weak or exclusionary governance risks to undermine legitimacy, while collaborative and inclusive governance fosters trust and support. Recent studies emphasize that effective PA governance must balance top-down regulation with bottom-up participation, ensuring that local actors are treated as partners rather than passive recipients of decisions (Mitincu et al., 2023). Traditional management models frame PAs in a dualism between state authority and market actors. This view is not consistently the optimal solution, as it represents an exclusionary model of governance for communities. This underline the importance of shared administration, whereby governance responsibilities are distributed across public institutions, community organizations, and social economy actors. This model reduces the "distance costs" between decision-making centers and local realities, while addressing both market and government failures (Sacchetti et al., 2023). In PAs, shared administration could enhance resilience by embedding local communities as co-producers of conservation and development outcomes. It encourages polycentric governance, redistributes responsibilities, and reduces social polarization by legitimizing conservation as a process grounded in cooperation and mutual accountability. This process assumes stakeholder participation as a key element in governance.

Stakeholder participation is now widely recognized as a cornerstone of sustainable environmental management. By integrating diverse knowledge systems and values, participation improves the quality and legitimacy of decisions (Reed, 2008). However, participation is not simply about consultation: best practice requires early and continuous involvement, systematic stakeholder analysis, two-way communication, and clear role allocation. In community-based natural resource management, such practices have been shown to foster ownership, regulatory compliance, and more durable outcomes (Dyer et al., 2014). Still, power asymmetries remain a major challenge, with dominant actors often sidelining marginalized groups such as women, youth, or ethnic minorities (Paletto et al., 2016). Innovative approaches like project networks—collaborative initiatives where stakeholders co-develop products or solutions—help address these imbalances, building trust and long-term "reputation networks" that sustain cooperation (Buffa et al., 2019).

Research stresses that involving residents in tourism governance is critical, as this is often the most significant economic activity associated with PAs, providing jobs and business opportunities, especially in marginalized or rural areas (Ndivo and Cantoni, 2016).when communities perceive tangible benefits and participate in decision-making, they are more likely to support conservation objectives (Bichler, 2021). Furthermore, destination development research shows that innovation in tourism emerges from collaborative networks of local governments, businesses, and residents, reinforcing the importance of inclusive governance in PA tourism systems (Komppula, 2016).

As seen, Protected Areas are complex systems, consisting of political institutions, local actors, ecosystem services, users, and natural resources. Beyond the governance model, these elements are interconnected, and actions taken within the "Protected Area" institution can have effects on both the other elements and the wider environment. For this reason, it is useful for understanding PAs is Ostrom's framework of Social-Ecological Systems (SESs), which conceptualizes resource systems as nested interactions between four subsystems (figure 3.2): the resource system (e.g., the park ecosystem), resource units (wildlife, water, forests), governance systems (rules and institutions), and users (local communities, tourists, stakeholders) (Ostrom, 2009).

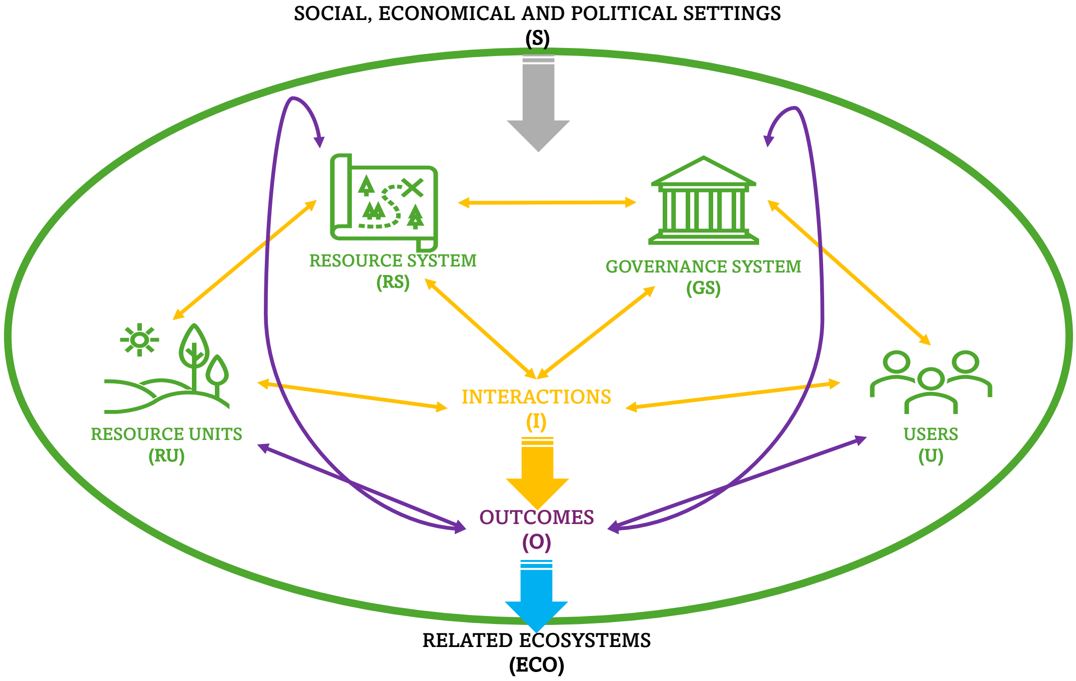


Figure 3.2: Social-Ecological Systems framework. Source: Ostrom (2007)

These components interact to generate ecological and social outcomes, which then feedback into the system. This approach underscores that the sustainability of PAs cannot be reduced to ecological management alone, but depends equally on governance design, local leadership, social capital, and community engagement. Ostrom demonstrated that resource users can self-organize to manage commons sustainably when enabling conditions exist, often outperforming centralized policies. Thus, viewing PAs as SESs highlights the need for adaptive, poly-centric governance tailored to local contexts (Ostrom, 2007). Adopting this SES perspective reveals that the resilience of PAs cannot be separated from the vulnerability of the communities that inhabit or surround them. Vulnerability studies emphasize that ecosystems and societies respond jointly to disturbances such as climate change or land-use pressures, and that the adaptive capacity of social institutions often determines whether ecological resilience can be maintained (Berrouet et al., 2018). In this sense, the capacity of a PA to protect biodiversity is inseparable from the ability of local communities to adjust livelihoods, manage resources collectively, and trust governance systems. Building on this, resilience thinking introduces the notion of spatial resilience, which underlines the role of connectivity and landscape structure in maintaining system stability.Protected Areas are more resilient when ecological processes are supported by spatial connections — such as habitat corridors — and when governance takes into account cross-scale interactions between ecosystems and human activities (Li et al., 2014). At the same time, scholars have called for more dynamic representations of human behavior within SESs. Moving from static categories of "resource users," recent advances in agent-based modeling (ABM) capture the heterogeneity of individual and institutional actors, their bounded rationality, and their adaptive strategies (Rounsevell et al., 2012). These models are particularly valuable for PAs where tourism is a dominant activity, as they can stimulate the feedback loops between tourist flows, infrastructure development, and ecological conditions (Petrosillo et al., 2006), especially under inclusive governance and adaptive planning, where both ecosystems and livelihoods are sustained (Lacitignola et al., 2007).Further research shows how PAs can be restructured as SESs by embedding residents and local authorities in decision-making processes, thereby linking ecological protection with community development (Silva et al., 2024). These cases demonstrate that governance models which acknowledge the socio-ecological character of PAs are better able to align biodiversity conservation with cultural values and economic revitalization.

Building on these insights, the study attempts to answer the following research questions: *how Protected Areas involve local communities in a Social-Ecological Systems perspective? How they connect with one another and with other social actors?* The main objective is to create an analytical framework for studying in detail aspects relating to the social capacity of PAs, combining the categories of the SES perspective and the evaluation criteria proposed by the WCPA for management effectiveness, for a multidimensional analysis that considers both ecological and social dynamics of PA governance.

3.3 Methodology

3.3.1 Analytical framework and Interview protocol

The integration of the SES perspective (Ostrom, 2009) with the WCPA framework (Hockings et al., 2006) is important because it enables a more comprehensive analysis of protected areas. While the WCPA framework provides a structured approach to evaluating management effectiveness through context, planning, inputs, processes, outputs, and outcomes, it tends to focus primarily on institutional performance and ecological results. By contrast, the SES framework emphasizes the interdependence between ecological systems, resource users, and governance arrangements, highlighting feedback loops and adaptive capacities. Combining the two frameworks makes it possible to (i) systematically evaluate how governance arrangements and management actions interact with ecological and social variables, (ii) assess the role of local actors and community participation as drivers of management effectiveness, and (iii) identify pressures and vulnerabilities arising from broader socio-economic and ecological contexts. This integrated approach thus strengthens the analytical capacity to study the social dimension of protected areas, acknowledging that their long-term effectiveness depends not only on ecological outcomes but also on legitimacy, inclusiveness, and resilience of governance systems. Table 3.2 presents the proposed correspondence between the WCPA assessment dimensions and SES categories, together with the indicators proposed for the study (compare with table 3.2 for a detailed list of SES variables). Context was linked to socio-economic settings (S1–S6) and related ecosystems (ECO1–ECO3) to assess external pressures; planning was mapped to governance system variables (GS1–GS8) to capture institutional alignment. Inputs were associated with governance and user attributes (U5–U9), while processes were linked to interaction variables (I1–I8), reflecting participatory decision-making. Outputs combined governance (GS5–GS8) and interactions (I1–I8), measuring rule implementation and management actions. Outcomes were matched to ecological and social performance (O1–O3; RU1–RU7; RS1–RS9). Finally, cross-cutting criteria connected users (U1–U4), resource systems, resource units, and ecosystems, emphasizing engagement and resource status. This integrated framework allows a holistic assessment of PAs, considering both governance effectiveness and socio-ecological dynamics.

WCPA Dimension	Relevant SES Categories	Proposed Integrated Indicator
Context (Design)	S (S1–S6), ECO (ECO1–ECO3)	Assessment of socio-economic and ecological pressures
Planning (Design)	GS (GS1–GS8)	Alignment between planning and institutional frameworks
Input (Adequacy)	GS, U (U5–U9)	Institutional and technological capacity
Process (Adequacy)	I (I1–I8)	Inclusiveness of decision-making processes
Output (Delivery)	I (I1–I8), GS5–GS8	Implementation of operational rules and management actions
Outcome (Delivery)	O (O1–O3), RU (RU1–RU7), RS (RS1–RS9)	Ecological and social performance outcomes
Cross-cutting Criteria	U (U1–U4), RS, RU, ECO	User engagement and resource status

Table 3.1: Analytical Framework: integration of WPCA evaluation criteria with Socio-Ecological Systems categories . Source: own adaptation from Hockings et al. (2006) and Ostrom (2009)

Basing on this framework, an interview protocol has been designed. Its structure follows the main dimensions of management evaluation—design, adequacy, and delivery—while embedding the SES categories that allow for a more comprehensive reading of governance, ecological, and social interactions (see Appendix B for the complete interview outline).

Section A collects general information on the protected area (e.g., size, institutional history, staffing) to contextualize responses. Section B addresses the design dimension, distinguishing between context (social, economic, ecological pressures, policy frameworks, and boundary issues) and planning (governance arrangements, inter-institutional collaborations, and project-based partnerships). In line with the SES framework, this section explores both structural characteristics and cross-boundary dynamics, including the role of initiatives and projects in fostering territorial cooperation. Section C corresponds to the adequacy dimension, focusing on inputs (governance composition, resource availability, user profiles) and processes (the degree of inclusiveness and participation in decision-making). These questions aim to capture the institutional and technological capacity of the PA as well as the openness of its governance system. Section D refers to the delivery dimension. The output component examines concrete management actions, monitoring practices, and enforcement mechanisms, while the outcome component assesses ecological and social impacts, including biodiversity conservation, resource sustainability, and perceived social benefits such as equity and accessibility. A final open-ended part invites suggestions for improving management effectiveness and governance support.

Through this structure, the interview protocol makes it possible to investigate not only the ecological performance of protected areas but also their inclusiveness, i.e., the ability to engage users, foster collaboration, and generate legitimate and resilient governance arrangements.

Social, Economic, and Political Context (S)	
S1 Eonomic development - S2 Demographic trends - S3 Political stability	
S4 Government policies on resources - S5 Market incentives - S6 Media organization	
Resource Systems (RS)	**Governance Systems (GS)**
RS1 Sector (e.g., water, forests, pastures, fish)	GS1 Government organizations
RS2 Clarity of system boundaries	GS2 Non-governmental organizations
RS3 Size of the resource system	GS3 Network structure
RS4 Human-made structures	GS4 Property-rights systems
RS5 Productivity of the system	GS5 Operational rules
RS6 Equilibrium properties	GS6 Collective-choice rules
RS7 Predictability of system dynamics	GS7 Constitutional rules
RS8 Storage characteristics	GS8 Monitoring and sanctioning processes
RS9 Location	**Users (U)**
Resource Units (RU)	U1 Number of users
RU1 Mobility of resource units	U2 Socioeconomic attributes of users
RU2 Growth or replacement rate	U3 History of use
RU3 Interaction among resource units	U4 Location
RU4 Economic value	U5 Leadership/entrepreneurship
RU5 Number of units	U6 Norms/social capital
RU6 Distinctive markers	U7 Knowledge of SES/mental models
RU7 Spatial and temporal distribution	U8 Importance of the resource
	U9 Technology used
Interactions (I) - Outcomes (O)	
I1 Harvesting levels of different users	O1 Social performance measures
I2 Information sharing among users	(e.g., efficiency, equity,
I3 Deliberation processes	accountability, sustainability)
I4 Conflicts among users	O2 Ecological performance measures
I5 Investment activities	(e.g., overharvested, resilience,
I6 Lobbying activities	bio-diversity, sustainability)
I7 Self-organization activities	O3 Externalities to other SESs
I8 Networking activities	
Related Ecosystems (ECO)	
ECO1 Climate Patterns - ECO2 Pollution Patterns	
ECO3 Inflows and outflows from the focal SES	

Table 3.2: Subset of variables. Source: Ostrom (2009)

3.3.2 Case study

The interview was designed to be submitted to representatives or operators of protected areas. Seven protected areas in central Italy were selected as case studies, linked together by a hiking trail, the *Cammino Naturale dei Parchi* (CNP).

This is a 430 km long itinerary (figure 3.3) established in 2016, which connects several protected areas and villages between Rome (left bottom of the figure) and L'Aquila (mid-top right of the figure). The aim was to create a network that promotes protection and enhancement of cultural, environmental, and religious heritage, and promotes the development of sustainable forms of tourism, that take into account the environmental, the social-cultural and the economic impact of walkers on territories (CNP, 2021). Although CNP does not have defined governance, Protected areas play a core role in promoting and maintaining the trail, as they are the main attraction. The trail crosses seven protected areas, including four regional parks, two nature reserves, and one national park (table 3.3).

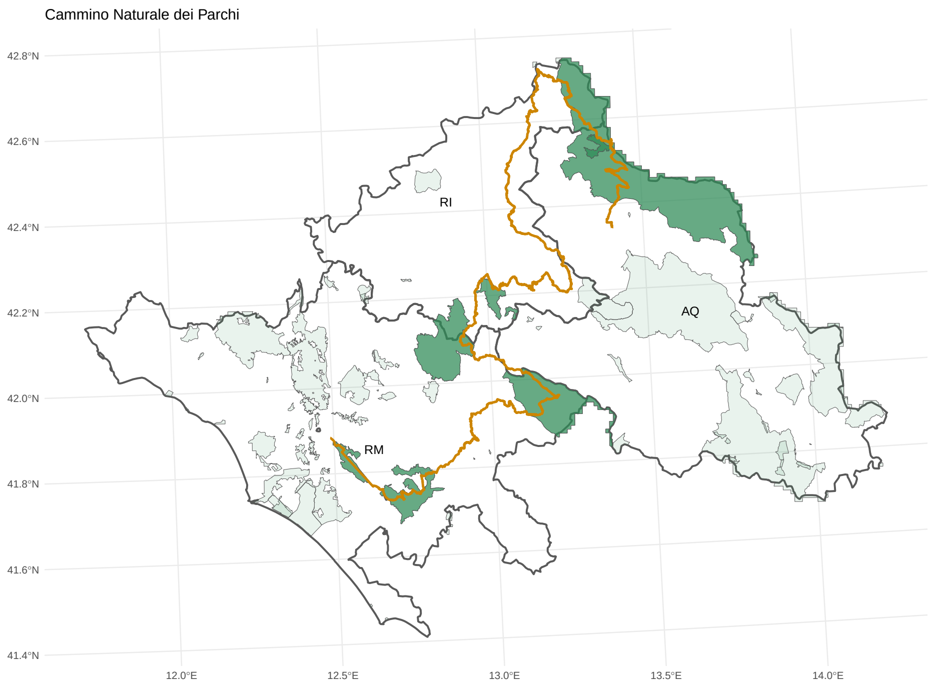


Figure 3.3: The *Cammino Naturale dei Parchi* and the crossed PAs. Source: CNP (2021), WDPA (2024)

Name	**Status Year**	**Designation**	**IUCN Category**	**Area (h)**	**N. Municipalities**
Parco regionale Appia Antica	1988	Regional/Provincial Nature Park	V	4580	3
Parco regionale dei Castelli Romani	1984	Regional/Provincial Nature Park	V	15000	15
Parco naturale regionale Monti Simbruini	1983	Regional/Provincial Nature Park	IV	30000	8
Parco regionale naturale dei Monti Lucretili	1989	Regional/Provincial Nature Park	IV	18000	13
Riserva naturale Monte Navegna e Monte Cervia	1988	Regional/Provincial Nature Reserve	V	3600	9
Riserva naturale delle Montagne della Duchessa	1990	Regional/Provincial Nature Reserve	IV	3540	1
Parco nazionale del Gran Sasso e Monti della Laga	1991	National Park	II	150000	44

Table 3.3: Details of Protected areas included in CNP

Hiking trails represent a valuable case for exploring how Protected Areas involve local communities and connect with broader Social-Ecological Systems. Trails function as both ecological and social infrastructures, linking parks, municipalities, and villages while providing opportunities for community engagement in tourism services, cultural promotion, and conservation practices (Campolo et al., 2016). In this case, CNP exemplifies how PAs operate as nodes within wider territorial networks. Cultural routes are increasingly recognized as complex systems that connect landscapes, institutions, and communities, generating formal and informal collaborations across administrative boundaries (Pattanaro and Pistocchi, 2020). By fostering partnerships among PAs, municipalities, associations, and residents, trails illustrate the polycentric governance configurations emphasized in Social-Ecological Systems. Recreational and cultural routes have been shown to diversify local economies, create employment, and enhance community pride while maintaining conservation goals (Forlani et al., 2023, Lukoseviciute et al., 2022). They further serve as narrative infrastructures, giving value to tangible and intangible heritage (Dayoub et al., 2020, Vada et al., 2023, Zhang et al., 2025). Overall, trails function not only as geographical linking, but also as social and cultural connectors that bring together ecological assets, governance institutions, and community actors across administrative boundaries.

In the study, seven representatives of CNP Protected Areas have been interviewed. The interviews have been then analyzed through ATLAS.ti Web (version 5.8.0, 2024). The territory under analysis is highly diversified from a geo-morphological, demographic, and social point of view. The responses reveal very diverse results, providing the research with remarkable insights and confirming the importance of specific context-based analyses when dealing with Social-Ecological Systems.

3.4 Results and Discussion

The responses highlight how different governance settings, demographic contexts, and resource availability shape both the involvement of local communities and the connections among parks and other social actors. For a detailed account of each interview, including park-specific contexts and management practices, see Appendix C.

In the peri-urban contexts of Appia Antica and Castelli Romani, rich cultural and natural heritage coexists with significant pressures from city traffic, tourism, and anthropization. These threats contrast with those affecting the mountain parks, such as Monti Simbruini, Monti Lucretili, Riserva Navegna-Cervia, Montagne della Duchessa, and Gran Sasso, where depopulation, economic fragility, and climate change were identified as the most pressing challenges. Despite these differences, all areas share a reliance on traditional rural practices and biodiversity conservation, which remain central to their ecological identity.

Governance arrangements strongly shaped the capacity of parks to respond to these pressures. Regional frameworks in Appia Antica, Castelli Romani, Simbruini, and Lucretili enabled a relatively high degree of collaboration with schools, universities, and associations, supporting more structured participatory processes. By contrast, the smaller municipalities managing Duchessa and Navegna-Cervia displayed weaker institutional capacity and limited partnerships, resulting in a less integrated approach. Gran Sasso, under ministerial governance, was able to achieve significant conservation results but struggled with fragmented responsibilities.

Resource constraints were evident across all sites, with staff shortages being the most recurrent issue. In several parks, including Appia Antica and Castelli Romani, the expertise gap was partially mitigated through partnerships with universities and the active role of volunteers. EU project funding provided crucial support to Monti Simbruini, enabling investments in digital tools and citizen science, while in areas such as Duchessa and Navegna-Cervia, technical and financial limitations curtailed opportunities for long-term planning and management.

Patterns of decision-making and implementation further reflected these asymmetries. Appia Antica demonstrated strong citizen and association engagement in planning processes, while Simbruini combined institutional governance with inclusive community projects. Lucretili also engaged in public consultations, whereas Duchessa and Navegna-Cervia showed only sporadic or project-specific participation. These differences translated into management outputs of varying scope and quality: Simbruini stood out for its expansion of hiking trails, digital platforms, and science outreach, while Lucretili emphasized cultural restoration and environmental education. By contrast, activities in Duchessa and Navegna-Cervia remained limited in frequency and scope, often depending on volunteers or schools.

Social and ecological outcomes mirrored this variability. Parks located closer to urban centers, such as Appia Antica and Castelli Romani, played a decisive role in providing recreational opportunities and fostering community identity, while simultaneously helping to contain urban sprawl. Simbruini emerged as the most successful example of socio-ecological revitalization, creating professional opportunities and reinforcing local well-being. Lucretili and Navegna-Cervia contributed to biodiversity protection but showed modest impacts on social dynamics. Duchessa remained strongly constrained by depopulation, while Gran Sasso maintained its role as a biodiversity stronghold, with mixed social results oscillating between revitalization and decline.

Finally, several cross-cutting trends emerged across all cases. Collaboration with other protected areas and expansion of citizen participation were seen as essential strategies for enhancing adaptive capacity. In the more fragile mountain areas, rediscovery of traditional rural practices, particularly pastoralism, was promoted as a way to address depopulation and strengthen local economies. Meanwhile, better resourcing of staff and reinforcement of surveillance were identified as critical needs, particularly in larger parks such as Gran Sasso and Lucretili. Overall, the comparative analysis underscored the tension between biodiversity conservation and socio-economic viability, while highlighting innovative pathways for adaptive and participatory management.

Figure 3.4 summarizes the main common insights from the case studies by mapping them onto the Social-Ecological Systems (SES) framework. It shows how Protected Areas operate as arenas where ecological resources (RS, RU) and social actors (U) interact under governance arrangements (GS), shaped by broader socio-economic and ecological contexts (S, ECO). The central role of participatory planning emerges as a mediating factor, encompassing ecosystem monitoring, volunteering, and collaborative decision-making. Outcomes (O) highlight the dual contribution of Protected Areas to both biodiversity conservation and socio-economic revitalization, while also fostering cultural identity and recreation. At the same time, external pressures such as depopulation, tourism, and climate change challenge system resilience, underlining the importance of inter-park cooperation and inclusive governance for long-term sustainability.

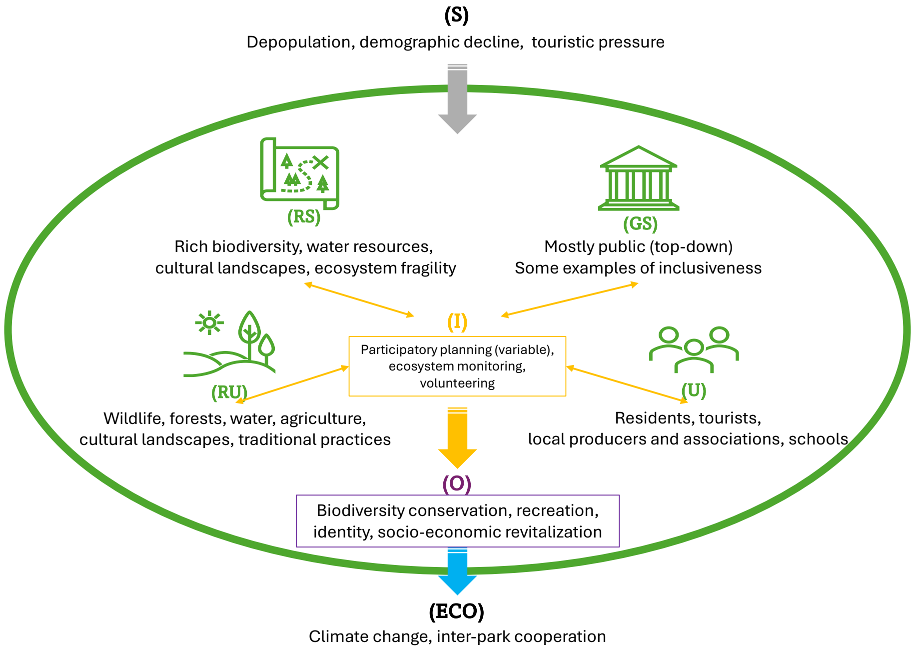


Figure 3.4: Core insights across Protected Areas according with the SES framework

Across the cases, park borders emerge less as fixed limits and more as porous frontiers where ecological, social, and governance dynamics flow in and out. While legal boundaries are clearly defined, pressures such as traffic, waste, urban sprawl, wildlife movements, and tourism routinely transcend them, forcing managers to engage with adjacent municipalities, metropolitan systems, and even international partners. In several parks, expansions or inter-park initiatives highlight how borders can be leveraged as connectors rather than barriers. Yet, where external linkages are weak,borders risk isolating protected areas and limiting their capacity to sustain vibrant communities. The responses reveal that effective management increasingly depends on treating borders as dynamic interfaces rather than rigid perimeters. In this sense, the *Cammino Naturale dei Parchi* (CNP) plays a central role in redefining park borders, transforming them from rigid perimeters into connective corridors that link protected areas, municipalities, and communities across Lazio and beyond. For parks like the Simbruini and Lucretili, the CNP has strengthened cooperation, stimulated sustainable tourism, and fostered a sense of shared identity among otherwise separate territories. In the Castelli Romani, it has encouraged partnerships with local associations and businesses, while in the Appia Antica it offers potential—though not yet fully realized—for broader territorial integration. Even in reserves with limited capacity, such as Navegna–Cervia or Montagne della Duchessa, the CNP provides a framework for collaboration and visibility that would otherwise be hard to achieve. The CNP emerges as a strategic instrument for overcoming the ecological and social limitations of individual park borders, weaving them into a regional network of connected landscapes and communities.

Overall, the results show that Protected Areas engage local communities within a Social-Ecological Systems perspective through diverse forms of participatory governance, ranging from strong citizen and association involvement in urban parks (e.g., Appia Antica, Simbruini, Lucretili) to more fragile and sporadic participation in depopulated mountain reserves (e.g., Duchessa, Navegna-Cervia), where weak social capital constrains engagement. Traditional rural practices, environmental education, and volunteer contributions further support community involvement, while external funding and citizen science enhance adaptive governance. At the same time, Protected Areas connect with one another and with broader social actors through cross-boundary collaborations, partnerships with municipalities, schools, universities, NGOs, and cultural associations, as well as through the Cammino Naturale dei Parchi, which transforms park borders into connective corridors linking territories, communities, and institutions. Overall, the study highlights PAs as dynamic socio-ecological nodes where conservation, governance, and community well-being intersect, emphasizing the importance of treating borders as interfaces that foster cooperation and resilience.

3.4.1 Discussion

The comparative analysis of the seven Protected Areas (PAs) along the Cammino Naturale dei Parchi (CNP), framed through the lens of the Social-Ecological Systems (SES) model and IUCN evaluation criteria, yielded some critical insights into the contemporary challenges and adaptive capacities of PA governance. These findings emphasize the fundamental tension between centralized authority and local context, the resource-dependency of effective community engagement, and the transformative potential of networked infrastructure in redefining territorial boundaries and identity.

The results clearly indicate that while governance structures across the seven PAs are predominantly public and formal (GS: Government Organizations), their top-down nature often translates into significant operational limitations and a disconnect from the local social-ecological realities, revealing a persistent failure of centralized state authority to provide adequate support and adaptive capacity at the ground level. The most pervasive evidence of this failure is the chronic and systemic issue of resource constraints and staff shortages experienced by virtually every park, regardless of its size or institutional status. This challenge is acutely felt even in the largest entities. Similarly, smaller Reserves, managed at the municipal level, are constrained by aging, minimal staff and rely heavily on temporary civil service volunteers for core operations. This dependency underscores a critical flaw in the centralized funding and staffing models, where ministerial or regional transfers prove insufficient for long-term operational sustainability. Furthermore, the centralized system often imposes bureaucratic rigidities that prevents adaptive management. Some Regional Parks, despite their own limitations, demonstrated greater agility in leveraging non-governmental organizations and fostering a degree of polycentric governance . These functional successes, however, are compensatory mechanisms—innovative ways to mitigate the inadequacy of core institutional inputs — rather than proof of a robust centralized system. The reliance on EU project funding and short-term collaborations highlights that sustained effectiveness is achieved despite the systemic weaknesses of the top-down administrative state, not because of its inherent strength.

The research findings reveal a pronounced variability in the level of community engagement and the resultant social-economic outcomes across the case studies. This variability is directly attributable to the specific Social, Economic, and Political Context and the institutional Inputs available to the PA. The engagement is not a universal deliverable of the PA mandate but rather a contingent output of favorable local conditions and resource mobilization. A clear dichotomy emerges between peri-urban and mountain contexts. Parks near Rome benefit from high population density and robust social capital, leveraging on strong grassroots efforts and a dense network of associations to achieve citizen and association engagement in planning processes. The rich network of cultural associations and the economic driver of tourism, provide tangible incentives for stakeholder collaboration. In stark contrast, the mountain reserves face the existential threat of depopulation and demographic decline. In these areas, the outputs remain limited, sporadic, and dependent on schools or volunteers. For these fragile SESs, the immediate challenge is not just conservation, but the mere maintenance of a human presence to prevent the abandonment of traditional pastoral landscapes, which is itself an ecological threat. This dependency highlights a core principle of the SES framework: the success of governance rules and deliberation processes is conditional on the availability of robust human and financial resources. Where parks can secure project funding to invest in digital tools and citizen science, they achieve significant social-ecological revitalization, creating professional opportunities and reinforcing local well-being. Where resources are limited, social outcomes remain modest, regardless of conservation efforts.

The Cammino Naturale dei Parchi (CNP) emerges as a pivotal connective infrastructure, acting as a functional override to the traditionally rigid institutional and geographical boundaries of the individual Protected Areas. The CNP demonstrates the vital role of cross-scale interactions in enhancing resilience and fostering a shared regional identity. Conceptually, the CNP transforms park borders from static perimeters into porous frontiers and connective corridors. This shift is crucial for addressing external pressures that routinely transcend legal limits. The trail provides a tangible, shared purpose that necessitates collaboration across administrative lines. Practically, the CNP has been a catalyst for strengthened cooperation and networking among diverse actors, like:

- Inter-Park Cooperation. It fosters a sense of shared identity and practical collaboration, particularly between neighboring entities and has been instrumental in linking the regional parks with the national park.
- Local Partnerships.The CNP led to the creation of a dedicated association involving businesses and tourism operators, promoting slow and experiential tourism or to launch new ideas to improve the local trails networks.
- Visibility and Resilience: Even in reserves with limited institutional capacity, the CNP offers a framework for enhanced visibility and collaboration that would otherwise be hard to achieve in isolation. By promoting tourism and cultural routes, the CNP helps diversify local economies and counter the effects of depopulation, thereby supporting the adaptive capacity of the mountain SESs.

The CNP acts as a shared narrative infrastructure, creating a sense of territorial ownership and shared identity that transcends the localism of individual villages and municipalities. This is a critical factor for long-term sustainability, as shared identity contributes directly to social capital and the willingness of actors to engage in collective-choice rule making. By creating a functional, multi-territorial unit focused on sustainable tourism and heritage, the CNP effectively strengthens the SES resilience by linking separate components into a larger, more viable network, offering a pathway to overcome the social and economic vulnerability inherent in fragmented, resource-poor mountain regions.

The study confirms that the effectiveness of Protected Areas is fundamentally determined by the polycentricity and resource availability of their Social-Ecological Systems. The reliance on top-down state authority results in persistent operational deficits, demanding that success be achieved through compensatory innovation at the local level. Furthermore, the capacity for community engagement is highly contingent on underlying demographic and economic health. Crucially, the Cammino Naturale dei Parchi offers a proven model for overcoming the inherent structural limitations of fragmented governance by creating a unifying, cross-boundary infrastructure that fosters networking, shared identity, and sustainable regional development.

3.5 Final Remarks

The cases examined along the Cammino Naturale dei Parchi highlights how Protected areas can be complex systems. They reveal themselves as Social-Ecological Systems where biodiversity, governance, and community life constantly interact. This complexity emerged clearly in the diversity of contexts studied: from peri-urban parks exposed to heavy pressures but rich in participation, to mountain reserves where depopulation and limited capacity constrain opportunities for engagement.

Looking at these realities through the lens of the SES perspective has proven particularly fruitful. It has allowed us to see parks not only as guardians of ecosystems but also as arenas of interaction, where institutions, residents, and cultural practices shape the very possibility of conservation. In this sense, the SES framework has offered a strength: it has captured the porous and dynamic nature of park borders, showing them less as rigid limits and more as frontiers where connections are built and resilience can grow. The analytical framework proposed in this study has served as a bridge between theory and practice. By integrating the categories of SES with the evaluation criteria of management effectiveness, it has provided a structured way to interpret the many layers of governance, participation, and outcomes that characterize protected areas. This approach has made it possible to answer the research questions in a systematic yet flexible way, shedding light on how parks involve local communities, how they connect with other actors, and how they navigate the pressures of their wider socio-economic contexts.

Of course, this work is not without limitations. The insights gathered through interviews have been rich, yet a deeper exploration—through more extensive fieldwork, repeated rounds of observation, and the inclusion of a wider set of stakeholders. Despite these limits, the overall outcome of the research is encouraging. The case of these Protected areas appear not as isolated institutions but as dynamic nodes of socio-ecological networks. Initiatives such as the CNP demonstrate the potential to transform borders into connectors, weaving together territories, communities, and ecosystems. In this lies both the challenge and the promise of protected areas: to hold together conservation and participation, ecological resilience and social vitality, in a shared path toward sustainability.

Conclusions

This thesis aimed to advance the research on Sustainable Regional Development (SRD) by adopting an interdisciplinary perspective and proposing innovative, robust, and policy-relevant solutions for addressing the systemic challenges of marginalized territories. More specifically, the overarching goal was to address the core argument that environmental, social, and economic challenges in marginalized territories stem fundamentally from coordination gaps, *i.e.*, situations in which both market and state mechanisms tend to misfire when needs, ecologies, and capabilities vary across places (Sacchetti and Borzaga, 2021). By focusing on territories of diverse characteristics through a Sustainable Regional Development (SRD) lens, this research aimed to build an approach that balances quality of life, ecological protection effectiveness, and community participation, consistent with the idea of SRD as a place-based operationalization of sustainable development's triple aim (Capello and Nijkamp, 2009).

This thesis's primary contribution to the SRD literature is the development and application of an integrated, three-dimensional operational framework for place-based policy. It moves beyond generic calls for balance by employing advanced empirical and institutional tools to: (i) diagnose coordination failures, identifying precisely where and why market and state mechanisms misfire in peripheral areas (Sacchetti and Borzaga, 2021); (ii) measure policy effectiveness at the margin, quantifying the local effect of place-based policies on ecological outcomes; (iii) provide institutional solutions, offering a deployable governance instrument essential for effective implementation, in line with polycentric approaches to governing complex territorial assets as common-pool resources and local public goods (Ostrom, 1990, 2010).

By centering coordination as the critical failure point, the thesis provides a perspective that bridges spatial econometrics, efficiency analysis, and Social–Ecological Systems (SES) thinking, transforming the abstract concept of SRD into a concrete, measurable, and institutionally grounded approach (Ostrom, 2009). Each of the three papers contributes distinct and actionable insights for guiding public expenditure and regional economic policy, especially concerning marginalized places.

The first chapter develops a decision-oriented, data-driven diagnostic to support targeted public investment in Inner Areas, within the broader context of the Italian place-based strategy (SNAI, 2013, 2021). The work carried out allows policymakers to move beyond simple rankings and to design interventions that are both domain-specific and spatially coordinated. In practical terms, the framework helps prioritize the dimensions that represent binding constraints (e.g., mobility, social security, and cultural enhancement) and indicates where investment should be planned at the scale of service basins and inter-municipal networks, increasing the effectiveness of per-capita spending and the efficiency of essential service delivery. By addressing structural bottlenecks and leveraging spillovers, the chapter provides an empirical basis for reducing spatial polarization and supporting inclusive territorial development, consistent with the view that peripheral conditions reflect distinct development potentials and policy needs (Kühn, 2015).

The second chapter contributes to natural capital valuation and regulatory policy design, using a boundary-focused Regression Discontinuity Design (RDD). The finding that protection benefits are spatially confined informs the need for economic instruments that extend conservation impact. Specifically, it advocates for public expenditure on connectivity measures that secure natural capital across the regional system. This is crucial for sustaining nature-based economic activities that rely on landscape integrity and for addressing externalities whose costs and benefits spread across space (Krugman, 1999).

The third chapter provides the institutional instrument for effective policy execution. It shows that polycentric, shared-administration models, where public authorities co-produce rules and services with community actors, lower distance and enforcement costs, consistent with the argument that durable governance depends on institution–context fit, collective-choice arrangements, and nested coordination across scales (Ostrom, 2000, 2010). Economically, this governance model generates non-market, positive externalities (local trust, social capital, empowerment) that strengthen collective action and raise the effectiveness of public spending, creating an enabling environment for resilient local production and entrepreneurship (Sacchetti and Borzaga, 2021).

A further contribution lies in the thesis's sequential mixed-method design, which links diagnosis, causal estimation, and institutional explanation into a coherent SRD research strategy. The quantitative chapters produce robust evidence on patterns and policy effects, but the qualitative institutional analysis completes the causal chain by explaining how coordination failures can be overcome in practice through rule-making, participation, and adaptive governance, *i.e.*, by moving beyond panaceas toward diagnostically grounded institutional design (Ostrom, 2009). In this sense, the thesis bridges empirical measurement and actionable reform: evidence is not treated as an endpoint, but as an input into governance design.

Taken together, the three chapters imply that SRD in marginalized territories should be pursued not through isolated projects, but through coordinated place-based portfolios that connect (1) targeted investment in well-being and services, (2) ecological-system integrity beyond administrative borders, and (3) institutional arrangements capable of sustained co-production—an approach consistent with SRD's emphasis on coherent portfolios combining ecosystem restoration, inclusion and capability-building, and competitiveness measures that serve (rather than override) social and ecological aims (Jovovic et al., 2017).

The methodology is integral to the thesis's overall argument about coordination failure. The sequential and mixed-method design serves a dual purpose: quantifying the problem while contextually explaining the solution. Chapters 1 and 2 employ quantitative methods to provide statistically robust, causal evidence of policy efficiency. This quantitative evidence, however, only identifies the symptoms and the limits of current regulation. The qualitative, institutional analysis in Chapter 3 completes the thesis by providing an essential institutional mechanism for overcoming these observed gaps. By exploring stakeholder interactions, governance processes, and collective action dynamics using the Social–Ecological Systems framework, the thesis uncovers how to institutionalize the participation necessary to bridge the coordination gaps identified in the first two chapters (Ostrom, 2009). This methodological integration is therefore the cornerstone of the thesis's strength, linking empirical diagnosis directly to actionable governance reform.

The study of territories' challenges is more critical than ever, given the pressures of climate change, persistent demographic decline, and widening socio-economic disparities—dynamics that jointly erode local capabilities and complicate long-term investment in marginalized regions (Jovovic et al., 2017). Marginalized territories hold immense environmental, social, and cultural capital that the current centralized, uniform policy approaches often fail to unlock.

In this context, the present research is positioned in the tradition of place-based policy, advocating for a radical shift from top-down mandates to a bottom-up, polycentric governance model. By demonstrating that coordination gaps are the root issue, the research offers a path forward: a Sustainable Regional Development approach that systematically measures territorial needs, secures ecological assets, and institutionalizes participation as a mechanism for co-production, in line with viewing placemaking as a social process of co-designing rules, uses, and stewardship with local actors (Akbar and Edelenbos, 2021, Ellery et al., 2021). Ultimately, transforming the consistent local success of individual initiatives into a broader strategy for regional sustainability depends on aligning governance and investment with the unique, relational nature of place, where values, identities, and stewardship shape policy fit and compliance (Dessein et al., 2016), and where integrated bundles of interventions can widen opportunities and diversify local economies (Theodoropoulou et al., 2009).

This thesis was developed as part of the Susteems doctoral program. The work carried out here is not only the result of three years of efforts, experiences, trials and errors. Above all, it is a tribute to my homeland, which has given me so much and to which I hope to give just much back. It is also a witness to my political choice to contribute, through research, to a more just and equitable society for all.

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Appendix A

List of Protected Areas

NAME	DESIG	IUCN CAT	STATUS YR	AREA
Riserva naturale Pantaniello	State Nature Reserve	Ia	1972	6.88
Riserva naturale Feudo Intramonti	State Nature Reserve	Ia	1972	893.08
Riserva naturale Quarto Santa Chiara	State Nature Reserve	Ia	1982	526.43
Riserva naturale Colle di Licco	State Nature Reserve	Ia	1971	102.96
'Parco nazionale dell''Abruzzo. Lazio e Molise'	National Park	II	1923	50635.65
Parco nazionale del Gran Sasso e Monti della Laga	National Park	II	1991	143133.29
Parco nazionale della Maiella	National Park	II	1991	74015.08
Monumento naturale Valle delle Cannuccete	Other Protected Natural Regional Areas	III	1995	19.96
Monumento naturale Palude di Torre Flavia	Other Protected Natural Regional Areas	III	1997	48.4
Monumento naturale La Selva	Other Protected Natural Regional Areas	III	2000	25.16
Momumento naturale Villa Clementi e Fonte Santo Stefano	Other Protected Natural Regional Areas	III	2002	6.69
Monumento naturale Gole del Farfa	Other Protected Natural Regional Areas	III	2007	102.87
Monumento naturale Madonna della Neve	Other Protected Natural Regional Areas	III	2007	2.75
Monumento naturale Lago di Giulianello	Other Protected Natural Regional Areas	III	2007	264.18
Monumento naturale Torrecchia Vecchia	Other Protected Natural Regional Areas	III	2007	446.85
Monumento naturale Parco della Cellulosa	Other Protected Natural Regional Areas	III	2006	100.08
Parco naturale regionale Monti Simbruini	Regional/Provincial Nature Park	IV	1983	29794.15
Parco regionale naturale dei Monti Lucretili	Regional/Provincial Nature Park	IV	1989	18259
Riserva parziale naturale dei Laghi Lungo e Ripasottile	Regional/Provincial Nature Reserve	IV	1985	3130.87
Riserva naturale Fara San Martino Palombaro	State Nature Reserve	IV	1983	4229.36
Riserva naturale Monte Rotondo	State Nature Reserve	IV	1982	1452.77
Riserva naturale di Macchiatonda	Regional/Provincial Nature Reserve	IV	1983	210.99
Riserva naturale Monte Velino	State Nature Reserve	IV	1987	3939.91
Riserva naturale del Lago di Campotosto	State Nature Reserve	IV	1984	1589.4
'Riserva naturale Lama Bianca di Sant'' Eufemia a Maiella'	State Nature Reserve	IV	1987	1397.03
Riserva naturale guidata Zompo lo Schioppo	Regional/Provincial Nature Reserve	IV	1987	1004.54
Riserva naturale delle Montagne della Duchessa	Regional/Provincial Nature Reserve	IV	1990	3308.82
Parco regionale naturale del Sirente - Velino	Regional/Provincial Nature Park	IV	1989	55130.24
Riserva naturale di Nazzano. Tevere - Farfa	Regional/Provincial Nature Reserve	IV	1979	721.86
Riserva naturale speciale delle Grotte di Pietrasecca	Regional/Provincial Nature Reserve	IV	1992	113.95
Riserva naturale regionale Tor Caldara	Regional/Provincial Nature Reserve	IV	1988	42.79
Riserva naturale Litorale romano	State Nature Reserve	IV	1987	15911.31
Riserva naturale statale Tenuta di Castelporziano	State Nature Reserve	IV	1979	5862.64
Riserva naturale del Monte Soratte	Regional/Provincial Nature Reserve	IV	1997	443.87
Riserva naturale guidata Gole di S. Venanzio	Regional/Provincial Nature Reserve	IV	1998	830.09
Riserva naturale guidata Gole del Sagittario	Regional/Provincial Nature Reserve	IV	1997	357.14
Riserva naturale guidata Monte Genzana e Alto Gizio	Regional/Provincial Nature Reserve	IV	1996	3114.47

NAME	DESIG	IUCN CAT	STATUS YR	AREA
Riserva naturale guidata Monte Salviano	Regional/Provincial Nature Reserve	IV	1999	710.17
Oasi di Macchiagrande	Other Protected Natural Regional Areas	IV	1987	239.34
Riserva naturale controllata Grotte di Luppa	Regional/Provincial Nature Reserve	IV	2005	89.68
Riserva naturale controllata Lago San Domenico	Regional/Provincial Nature Reserve	IV	2005	52.93
Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe	World Heritage Site (natural or mixed)	Not Applicable	2007	87074.19
Lago di Nazzano	Ramsar Site. Wetland of International Importance	Not Reported	1976	341.95
Lago di Barrea	Ramsar Site. Wetland of International Importance	Not Reported	1976	333.83
Parco urbano Pineta di Castel Fusano	Other Protected Natural Regional Areas	V	1980	935.36
Parco regionale dei Castelli Romani	Regional/Provincial Nature Park	V	1984	9107.75
Parco suburbano Valle del Treja	Regional/Provincial Nature Park	V	1982	599.06
Riserva naturale guidata del Fiume Vera	Regional/Provincial Nature Reserve	V	1983	36.45
Riserva naturale Monte Navegna e Monte Cervia	Regional/Provincial Nature Reserve	V	1988	3569.48
Parco naturale regionale Appia Antica	Regional/Provincial Nature Park	V	1988	3170.27
Parco regionale urbano Pineto	Regional/Provincial Nature Park	V	1987	167.33
Riserva parziale naturale Monterano	Regional/Provincial Nature Reserve	V	1988	1042.82
Parco regionale urbano di Aguzzano	Other Protected Natural Regional Areas	V	1989	60.28
Riserva naturale di Monte Catillo	Regional/Provincial Nature Reserve	V	1997	1319.66
Riserva naturale di Nomentum	Regional/Provincial Nature Reserve	V	1997	827.46
Riserva naturale della Macchia di Gattaceca e Macchia del Barco	Regional/Provincial Nature Reserve	V	1997	996.83
Riserva naturale del Laurentino Acqua Acetosa	Regional/Provincial Nature Reserve	V	1997	166.86
Riserva naturale della Valle dei Casali	Regional/Provincial Nature Reserve	V	1997	466.7
'Riserva naturale dell''Insugherata'	Regional/Provincial Nature Reserve	V	1997	740.89
'Riserva naturale Valle dell''Aniene'	Regional/Provincial Nature Reserve	V	1997	648.86
Riserva naturale di Decima Malafede	Regional/Provincial Nature Reserve	V	1997	6103.34
Riserva naturale della Marcigliana	Regional/Provincial Nature Reserve	V	1997	4676.51
Riserva naturale della Tenuta dei Massimi	Regional/Provincial Nature Reserve	V	1997	861.41
Riserva naturale di Monte Mario	Regional/Provincial Nature Reserve	V	1997	203.72
Riserva naturale della Tenuta di Acquafredda	Regional/Provincial Nature Reserve	V	1997	256.33
Riserva naturale provinciale Villa Borghese	Regional/Provincial Nature Reserve	V	1999	39.88
Parco naturale regionale del complesso lacuale Bracciano - Martignano	Regional/Provincial Nature Park	V	1999	16650.88
Monumento naturale Quarto degli Ebrei e Tenuta di Mazzalupetto	Other Protected Natural Regional Areas	V	2000	185.06
Monumento naturale Galeria Antica	Other Protected Natural Regional Areas	V	1999	31.27
Parco naturale di Veio	Regional/Provincial Nature Park	V	1997	15049.89
'Parco dell''Inviolata'	Regional/Provincial Nature Park	V	1996	534.98

Appendix B

Interview outline

Section A – General Information

- Protected Area interviewed
- Size (territorial extension)
- Number of employees / volunteers
- Year of establishment

Section B – Design: Context and Planning

Context (S, ECO)

- How is the territory characterized from a demographic, economic, and environmental perspective?
- What are the relevant government policies for the management of the Protected Area (PA)?
- What are the main threats (environmental, social, economic) affecting the PA?
- Do the institutional boundaries coincide with the geographical ones?
- Are there characteristics, policies, or threats that also concern the immediately surrounding area?

Planning (GS)

- How is the management of the area planned? Which actors are involved?
- Are there collaborations created ad hoc within specific projects?
- Are there formal or informal relations with other territorial entities? Which ones? In what do they collaborate?
- Has the creation and promotion of the Cammino Naturale dei Parchi influenced collaborations among local stakeholders?

Section C – Adequacy: Inputs and Processes

Inputs (GS, U)

- How is the governance of the authority composed?
- What resources (financial, technical, human) are available for management? Are there also informal tools?
- How many and what types of users access the area's resources?

Processes (I)

- Can decisions derive from inclusive and participatory processes? On which occasions?

Section D – Delivery: Outputs and Outcomes

Outputs (I, GS)

- What concrete actions have been implemented in recent years (e.g., conservation, environmental education)?
- Are there documentable results? Are they monitored? Does monitoring also include the users' perspective?
- Is there a system of gradual sanctions to ensure the achievement of objectives?

Outcomes (O, RS, RU)

- To what extent are management objectives being achieved?
- What are the impacts on natural resources (e.g., biodiversity, regeneration)?
- What is the perception of social benefits (e.g., resources, equity, accessibility, participation)?

Suggestions

- What would improve management effectiveness?
- What political or technical support would be useful?
- Other ...

Appendix C

Interviews' summaries

Appia Antica Regional Park

SECTION A – General Information

The Appia Antica Regional Park is a highly unusual protected area compared to other parks in Lazio. Its nature is twofold: on the one hand, it is an urban park embedded in the monumental heart of Rome and closely tied to some of the most famous archaeological areas; on the other, it is a countryside and agricultural park, especially in the southern portions of its territory. The park was established in 1988 thanks to strong grassroots efforts from citizens and intellectuals. However, it obtained an official management authority only in 1998. Following its expansion in 2018, the park now covers approximately 4,580 hectares across the municipalities of Rome, Ciampino, and Marino. Today it is managed by a small team of regional employees, supported by an important network of associations and volunteers.

SECTION B – Design: Context and Planning

The park stands out for its extraordinary concentration of archaeological, historical, and cultural heritage, which earned it recognition as a UNESCO World Heritage Site in 2022. At the same time, it preserves agricultural and natural ecosystems, all within and around densely populated neighborhoods. This unique setting also creates significant challenges. Above all, heavy car traffic, particularly in the urban stretch of the Appian Way, is the most pressing issue. Other threats include the risk of illegal construction (though currently well contained), overcrowding during holidays and long weekends, and certain issues related to fauna management, such as the large rabbit population in the Caffarella Valley. While the institutional boundaries of the park are clear, in practice its activities and challenges often extend to adjacent areas. Past expansions were deliberately aimed at halting new urban development and protecting vulnerable land.

Planning the park's management involves a wide range of actors: the regional institution, municipalities, the Archaeological Park of the Appian Way (under the Ministry of Culture), universities, local associations, and citizens. Collaborations include formal agreements with universities for environmental and geological studies, partnerships with environmental NGOs and neighborhood associations, as well as continuous dialogue with Rome's municipal districts and even the Vatican for the management of the catacombs. The Cammino Naturale dei Parchi is viewed as a promising opportunity to strengthen connections with other protected areas, particularly the nearby Castelli Romani Regional Park, though its potential has not yet been fully realized.

SECTION C – Adequacy: Inputs and Processes

The park's governance is regional, as part of Lazio's system of protected natural areas. Financial resources come mainly from the Region, but staff shortages remain a serious obstacle. For this reason, the contribution of volunteer groups and associations is essential, alongside the active role of citizens themselves. Park users are diverse: local residents, Italian and foreign tourists, and many schools from all over Lazio (and beyond), often involved in specific educational projects.

Decision-making frequently relies on participation. For example, a participatory planning process was organized for a new access point on Via Cilicia, where citizens directly contributed ideas and proposals. Regular roundtables are also held with associations. Local communities do not merely benefit from the park but actively claim a role in shaping its development, reporting issues and suggesting improvements.

SECTION D – Delivery: Outputs and Outcomes

In recent years the park has implemented a wide range of concrete actions: the creation of wetlands in the Caffarella Valley, monitoring of birdlife and wild fauna, environmental education projects for schools, guided tours such as "Open Gates" to normally inaccessible monuments, and cultural or musical events hosted at the Cartiera Latina (the park's headquarters) and the Casa del Parco in the Caffarella.

These initiatives have achieved strong citizen participation and increasing engagement from tourists and schools. However, there is no structured system for measuring results: evaluation tends to be informal, based on internal discussions and feedback from users.

The park's impact is evident on both environmental and social levels. Ecologically, it has supported biodiversity through new habitats and monitoring projects, although issues such as traffic and fauna management remain problematic. Socially, the park is widely recognized as a "green lung" for Rome, a place of recreation and well-being that enhances the quality of life for nearby neighborhoods. Local residents are well aware of this value and often push the park authority to do more in terms of protection and promotion. The active involvement of communities and associations is thus one of the park's most distinctive and innovative strengths.

Suggestions and Future Perspectives From the interview, several needs emerge clearly: stronger collaboration with other parks (especially the Castelli Romani Park), more decisive action on the traffic issue, greater human resources, and more structured monitoring systems. At the same time, maintaining and expanding citizen participation is crucial—not only to ensure effective shared management but also to strengthen the park's role as an "extended community," which represents its greatest asset.

Parco Regionale Castelli Romani

SECTION A – General Information

The Castelli Romani Regional Reserve, established in 1984, is one of the largest and most complex protected areas in Lazio. It extends across fifteen municipalities with a population of around 350,000–400,000 residents, in addition to other satellite towns. The strong demographic pressure, combined with its proximity to Rome, makes the park a natural area under constant urbanization dynamics and intense land use. The territory is largely forested, with extensive chestnut woods of significant economic and cultural value, alongside residual patches of native vegetation. Two lakes – Albano and Nemi – enrich the landscape, with important touristic, ecological, and naturalistic functions. The area is used throughout the year, thanks to its mild climate and a dense network of hiking trails, mountain bike routes, and historic itineraries such as the Via Francigena and the CNP.

SECTION B – Design: Context and Planning

The park is characterized by a wide variety of functions and pressures: forestry, agriculture (vineyards, olive groves, small fruit cultivation), cultural and gastronomic tourism, and recreational and sporting activities. Alongside these vocations, the area faces significant environmental challenges. The main threats include climate change, which manifests through extreme weather events and the worrying decline of the water levels in lakes Albano and Nemi; the illegal dumping of waste, exacerbated by the presence of major roads crossing the area; and wildlife management issues, especially concerning wild boars, which are increasingly drawn to urban settlements and household waste. These issues go beyond the park's formal boundaries, highlighting the permeability between the protected area and the surrounding metropolitan context.

From a management perspective, the park oversees permits and authorizations for forestry activities, regulating land use. However, its land management plan, approved many years ago, was never formally enacted, meaning that operations still rely on guidelines without binding force. The complexity of the area nonetheless requires constant coordination with local municipalities, the Metropolitan City of Rome, and other supra-local institutions. Governance also intertwines with the social and economic fabric of the Castelli Romani: cultural associations, cooperatives, sporting organizations, and food and wine producers actively contribute to the park's activities. Enological and gastronomic tourism has become an important economic driver, alongside agriculture and forestry.

SECTION C – Adequacy: Inputs and Processes

Financial resources come mainly from the Lazio Region and project-based funding, including EU programs and local rural development initiatives (GAL). Staffing is limited, and internal expertise is not always sufficient to guarantee systematic monitoring. For this reason, collaborations with universities, research institutions, and associations play a crucial role. Park users are highly diverse: residents, day-trippers from Rome, hikers, sports enthusiasts, cultural associations, and schools. Human pressure is therefore constant, with peaks during weekends and special events.

Decision-making generally follows institutional channels, but there are also experiences of broader participation. The park often acts as a catalyst for initiatives by associations and cooperatives, supporting educational projects, guided tours, cultural activities, and outreach programs. The Cammino Naturale dei Parchi has encouraged cooperation both with the Appia Antica Park, due to territorial continuity, and with the regional environment and tourism directorates, through joint promotional activities. An association dedicated to enhancing the trail in the Castelli Romani has also been created, involving businesses and tourism operators to promote slow and experiential tourism.

SECTION D – Delivery: Outputs and Outcomes

In recent years the park has carried out several significant interventions, including: securing and maintaining trail segments; installing video surveillance systems to combat illegal waste dumping; wildlife management, particularly wild boar control through capture and relocation; tourism promotion projects linked to the hiking trails; cultural and educational initiatives with local associations. Institutional monitoring focuses mainly on habitats and species covered by European directives. However, the lack of consistent funding prevents continuous and systematic data collection. Recently, the park has experimented with citizen involvement through citizen science initiatives, such as biodiversity monitoring days and user satisfaction surveys.

The park has played a decisive role in containing urbanization and preserving ecosystems crucial to the metropolitan area of Rome. Despite limitations in resources and expertise, it has ensured the protection of forests, lakes, and agricultural landscapes that would otherwise have been at serious risk of exploitation. Socially, the park is perceived as a common good, widely used for leisure, sports, and tourism. Over the years, the number of associations and cooperatives operating in the area has grown exponentially, enriching the cultural and environmental offer and strengthening ties with local communities.

Suggestions and Future Perspectives

The interview highlights several priorities: adopting updated and binding land management tools; improving waste management and regulating visitor flows; developing more inclusive governance for the hiking trails, with stronger public-private partnerships; enhancing monitoring systems, overcoming fragmented competences; reinforcing communication and environmental education to promote responsible behavior among citizens. The future of the park depends on its ability to reconcile conservation with public use, ensuring that human pressure does not undermine the very natural and landscape values it was created to safeguard.

Parco Regionale Monti Simbruini

SECTION A – General Information

The Monti Simbruini Regional Park, established in 1983, is among the earliest and largest regional parks in Lazio. Covering around 30.000 hectares, it extends across eight municipalities. With a population of only about 11,500 inhabitants (8,500 of whom live in Subiaco), the Park is one of the least urbanized in Lazio. Its vast forests, mountainous landscapes, and limited human settlements make it a largely intact natural area, with a strong ecological and cultural identity.

SECTION B – Design: Context and Planning

The park is characterized by exceptional biodiversity. It hosts emblematic species such as the Marsican brown bear, the wolf, red deer (reintroduced in the 2000s and now numbering around 250–300 individuals), golden eagles, and the peregrine falcon, which also serves as the park's symbol. The park is home to some of Europe's largest beech forests and is a vital source of water for the Aniene River, thanks to its karst landscapes. This rich biodiversity also includes rare orchids, which flourish during spring and highlight the pristine quality of the territory. Importantly, the park has remained relatively untouched by pollution, benefiting from decades of protected status. Economically, the park has focused on developing sustainable tourism centered on hiking, walking, and cycling. Over 350 kilometers of marked trails form the backbone of its strategy, complemented by a dedicated in-house carpentry workshop producing and recycling wooden signage. This has allowed for safe and accessible trails while promoting a vision of "slow tourism" in nature. The park also spearheaded the idea of Cammino Naturale dei Parchi, a long-distance route connecting Rome with the Gran Sasso and Monti della Laga National Park. The initiative reflects a vision of linking protected areas into a coherent network, promoting nature immersion, and fostering regional identity.

Governance and planning involve balancing conservation with sustainable development. The park collaborates closely with municipalities, associations, local businesses, and volunteers. It has successfully stimulated the creation of professional guides, B&Bs, hostels, and outdoor activity enterprises (rafting, climbing, mountain biking), diversifying economic opportunities in response to reduced snowfall and declining winter tourism.

SECTION C – Adequacy: Inputs and Processes

The park is an autonomous entity but relies heavily on the Lazio Region for funding. Its annual budget of around €425,000 covers staff and operational costs, while investments depend on project-based funding at regional, national, and EU levels. Staff includes around 55 people, with about 20 dedicated to trail maintenance and monitoring, 10 park rangers, and the remainder in technical and administrative roles. Additional support comes from civil service volunteers, who have played a crucial role in projects like the Cammino Naturale dei Parchi, environmental education, and biodiversity monitoring.

Decision-making combines institutional structures (director, president or commissioner, board) with active community participation. The park has pioneered inclusive projects, such as designing three accessible trails for people with disabilities and acquiring special equipment to facilitate assisted hiking. Civil service volunteers are described as a major "added resource," contributing creativity, digital tools (trail mapping, GIS data), and even professional expertise that often continues beyond their service year. This has created a virtuous circle of youth involvement, professional training, and innovation.

SECTION D – Delivery: Outputs and Outcomes

In recent years, the park has: expanded and maintained a 350 km hiking network; created digital trail maps and downloadable GPS tracks for smartphones; promoted outdoor events, including trail races and citizen science activities; supported the growth of local businesses in hospitality and outdoor sports; initiated inclusive tourism projects (accessible trails); developed collaborations across Lazio's protected areas through the CNP. Monitoring is conducted partly through scientific studies (fauna counts, habitat protection) and partly through feedback from users and associations.

The park has succeeded in transforming itself from a largely winter-focused destination into a hub of year-round sustainable tourism. Visitor numbers have grown steadily since the mid-2000s, with strong increases during and after the COVID-19 pandemic. The creation of professional opportunities—guides, outdoor companies, hospitality—has revitalized the local economy. Environmentally, the park has preserved large forested areas and supported the recovery of key species. Socially, it is perceived as a shared resource that fosters well-being, community pride, and active participation.

Suggestions and Future Perspectives

The interview highlights several needs: Strengthening monitoring of forestry activities; ensuring sustainable and controlled logging practices; expanding cooperation beyond park boundaries to involve more municipalities and communities, building on the momentum of the CNP; increasing investment in climate change adaptation, particularly concerning water scarcity and declining snow cover; continuing to foster inclusive and sustainable tourism, balancing conservation with visitor growth. The Simbruini Mountains Regional Park demonstrates how protected areas can serve as engines of sustainable development, combining ecological preservation with social and economic vitality through long-term vision, participation, and innovation.

Parco Regionale Monti Lucretili

SECTION A – General Information

The Monti Lucretili Regional Park is one of the largest protected areas in Lazio, covering over 18,000 hectares. Since 2016, the park authority also manages the smaller Inviolata Regional Park (about 500 hectares, with an archaeological character), as well as various Natura 2000 sites (ZPS and ZSC). Altogether, the authority oversees more than 20,000 hectares of protected land. The park includes 13 municipalities, mostly small villages, with a combined population of 35,000–40,000 residents. The only larger center is Palombara Sabina (around 13,000 inhabitants), which also hosts the park headquarters. In general, these are commuter towns: many residents work in Rome or in nearby provinces, while local economies rely mainly on small-scale activities such as oil production in the Sabina area, cherry cultivation, small-scale pastoralism, honey production, and rural tourism. In contrast, the Inviolata Park lies in Guidonia Montecelio, Lazio's second-largest municipality with over 90,000 inhabitants, representing a very different urban context.

SECTION B – Design: Context and Planning

The Lucretili territory is diverse: karst formations, extensive beech forests, wetlands such as the Percile lakes (recognized as Ramsar sites), and a wide presence of water resources. Its symbol is the Styrax officinalis, a rare plant found only in this area. Wildlife includes wolves and a pair of golden eagles nesting near Licenza, both regularly monitored by park rangers. There is also an abundance of wild orchids, including rare species. Main threats include: demographic decline and depopulation of small villages, leading to the loss of traditions, associations, and cultural heritage; Wildfires, particularly in summer, though usually limited in scale; illegal construction, generally small rural structures built without authorization; poaching, which persists despite protected status; wild boar management, a pressing issue across Lazio, now addressed through selective capture programs. The park authority is structured with a political body (president and board), an administrative director, technical staff, and park rangers. In addition, the "Park Community" (mayors of the 13 municipalities) serves as a consultative body, particularly in approving the land-use plan and the multi-year socio-economic program.

Planning tools include the land management plan (defining zoning and protection levels), the park regulation (what is allowed and prohibited), and the multi-year socio-economic program (developed jointly with municipalities). These ensure a balance between conservation and local development. Collaboration is extensive: the park works closely with municipalities, schools, associations, universities (including projects with the CNR), and cultural institutions like the archaeological site of Horace's Villa in Licenza. Events, education programs, and citizen initiatives form an important part of its outreach. The CNP has been crucial in strengthening inter-park cooperation and connecting with external stakeholders (municipalities, sponsors, associations). The Lucretili Park also recently launched the idea of a Lucretili Ring Trail, a circular route linking all 13 municipalities, designed to encourage sustainable tourism and strengthen ties among local communities.

SECTION C – Adequacy: Inputs and Processes

The park depends mainly on Lazio Region transfers for operating costs (staff, utilities, fuel). Project-based funding supports infrastructure, events, and trail maintenance. Recent regional programs have financed trail safety upgrades and the promotion of recognized hiking routes (such as the Cammino di San Benedetto and the CNP). Staff includes technical and administrative employees, rangers, and a strong presence of civil service volunteers. Volunteers and trainees also support research, environmental education, and promotion.

Participation is embedded in planning: public consultations are mandatory for the adoption of land-use plans and multi-year programs. Draft documents are published online, and citizens can submit observations or proposals, some of which lead to changes (e.g., expanding protection to overlooked areas). The park is also working toward the European Charter for Sustainable Tourism (CETS), which requires broad stakeholder involvement (associations, municipalities, tourism operators). Public meetings and technical tables have produced project proposals, which are now under EU verification for final certification. Transparency is ensured by publishing decisions, permits, and performance indicators. Staff performance is evaluated quarterly, and results are made publicly available.

SECTION D – Delivery: Outputs and Outcomes

Recent achievements include: Restoration and safety measures on trails; promotion of hiking and horseback riding routes; environmental education programs with local schools; establishment of three local museums; partnerships with associations and municipalities for cultural and natural events; monitoring of flora and fauna (wolves, eagles, orchids); development of the Lucretili Ring Trail; events such as "Summer in the Parks" or "Christmas in the Parks" are funded through annual regional calls and attract a wide audience.

The park plays a vital role in preserving a relatively intact natural area close to Rome, preventing uncontrolled development and fostering rural traditions. Its actions have helped maintain ecosystems, biodiversity, and local heritage while offering recreational opportunities to families, hikers, organized groups, and nature enthusiasts. Socially, the park fosters a sense of shared identity and encourages sustainable tourism. Families visit villages and museums, while organized hiking groups (CAI, Federtrek) regularly use the trails. Citizen participation in planning and events has strengthened ties between the park and its communities.

Suggestions and Future Perspectives

Key challenges and prospects include: Addressing depopulation and strengthening local economies; expanding cooperation beyond park borders, involving Tivoli and neighboring reserves like Monte Catillo; enhancing wildlife and forest monitoring, especially regarding wild boar and fire risk; supporting sustainable tourism with affordable accommodations and integrated trail systems; securing stable funding to complement project-based resources. Overall, the Lucretili Mountains Regional Park demonstrates the potential of protected areas to safeguard biodiversity, sustain cultural heritage, and stimulate local development through innovation, partnerships, and community involvement.

Riserva Naturale Monte Navegna e Monte Cervia

SECTION A – General Information

The Monte Navegna and Monte Cervia Nature Reserve extends over approximately 9,000 hectares across two municipalities in the mountainous heart of Lazio. It was established in the early 1990s and is managed at the municipal level rather than through a dedicated park authority. This governance model means that local municipalities play a direct role in decisions and management, often supported by civil service volunteers. Staffing is very limited—around eight employees in total, many of them close to retirement age. Much of the work, especially small-scale maintenance, relies on volunteers and civil service projects.

SECTION B – Design: Context and Planning

The reserve lies in an area marked by depopulation and demographic decline. Across nine small towns connected to the reserve, the permanent population numbers only around 1,500 people, the vast majority of whom are elderly. The outmigration of younger generations has left villages sparsely populated, with many homes abandoned. Economically, the area is fragile. Local businesses—restaurants, small-scale tourism activities, and agriculture—struggle to find workers. Tourism is highly seasonal, with some activity around Easter and in the summer, but otherwise very limited. Environmentally, however, the reserve is extremely rich. It hosts the full spectrum of Apennine wildlife: wolves, roe deer, wild boar, raptors, amphibians, and diverse birdlife. Biodiversity is high, in part because the territory remains relatively untouched by intensive human activity. The greatest threat comes not from overexploitation, but from abandonment: loss of traditional pastoralism, disuse of historic trails and the abandonment of cultivated fields. This shift risks turning the entire area into forest, which could lead to the disappearance of species dependent on open habitats, as well as increased wildfire risk.

The reserve's planning is modest and primarily tied to local municipalities. Collaborations are mostly informal and include associations that organize occasional environmental events or excursions. Larger-scale partnerships are rare. The CNP crosses the reserve, but its impact has been limited. Unlike the Cammino di San Benedetto, which has fostered new services and tourism, the CNP has not significantly stimulated accommodations or collective initiatives, mainly due to the scarcity of local infrastructure and the lack of younger entrepreneurs.

SECTION C – Adequacy: Inputs and Processes

Funding comes mainly from the Lazio Region, but it is limited. Technical and human resources are minimal, and most monitoring and maintenance are carried out with the help of rangers and civil service volunteers. The small workforce, aging staff, and lack of generational renewal represent structural challenges.

Decision-making is pragmatic and often ad hoc. Public participation is rare, though occasional collaborations with schools (mostly from Rieti, since local schools have closed) and with short-term summer camps do take place. Monitoring of fauna—particularly wild boar, ungulates, and wolves—is one of the few structured activities. Citizen involvement is minimal, although local residents sometimes participate in specific monitoring exercises. Overall, participation is constrained by the demographic decline and lack of young people in the area.

SECTION D – Delivery: Outputs and Outcomes

The reserve organizes occasional environmental education activities, short-term summer camps, and biodiversity monitoring projects. Events are sporadic and not tied to a stable annual program. Trail maintenance and small interventions are carried out as resources allow.

Biodiversity remains rich, and some species (wolves, roe deer) have increased in presence, partly due to the abandonment of agricultural land. However, this same abandonment has reduced habitat diversity, threatening smaller species and pastoral landscapes. Socially, the reserve struggles to make a strong impact due to the limited local population and lack of tourism infrastructure. Restaurants and businesses often survive only through family management, with many closing after a short time. The broader perception is that the reserve alone cannot reverse depopulation or revive the local economy.

Suggestions and Future Perspectives

The main priority is to address depopulation by incentivizing new residents, entrepreneurs, or even foreign families to settle in the area. Supporting small businesses, crafts, and rural activities would create economic movement and help sustain local life. Without such incentives, the villages risk becoming "cemeteries of houses." The interviewee suggests that a stronger integration of migrants and foreign families could also help revive these communities, as has happened in parts of Tuscany. Combined with better support for local entrepreneurs, this could counterbalance aging demographics and create a new basis for sustainable development. Ultimately, the interview emphasizes that nature here has been preserved largely thanks to past generations who lived and worked the land. The future of the reserve depends on finding a balance between conservation and the human presence needed to maintain biodiversity and cultural landscapes.

Riserva Naturale Montagne della Duchessa

SECTION A – General Information

The Montagne della Duchessa Nature Reserve, established in 1990, covers about 3,500 hectares within the municipality of Borgorose, on the border between Lazio and Abruzzo. The territory ranges from 900 meters up to over 2,200 meters in altitude, creating a steep vertical gradient that strongly shapes accessibility and use. The local population is concentrated in Borgorose, which maintains a relatively stable number of residents—around 4,000–5,000 inhabitants. Unlike other parts of the Rieti province, depopulation has been less severe here, thanks to good transport connections (motorways, railways) that allow commuting to Rome, L'Aquila, and nearby centers. Tourism remains modest but has grown in recent years, especially thanks to the Cammino dei Briganti, a circular trail that offers a more accessible and appealing route than the long-distance Cammino Naturale dei Parchi.

SECTION B – Design: Context and Planning

The reserve is rich in biodiversity, with around 1,300–1,400 plant species and all the key vertebrates of the Apennines: wolves, wild boars, deer, bears, and raptors. It shares with the Sirente-Velino Regional Park the largest griffon vulture colony in central Italy, along with golden eagles and other emblematic species. The main threats are not urbanization but changes in traditional rural practices. Sheep farming has declined, replaced by cattle, which require less presence at high altitudes but provide weaker ecological benefits. Abandonment of pastures and transhumance risks reducing habitat diversity and increasing fire risk. Economically, the area is shifting toward services and tourism, with limited agricultural and livestock activities compared to the past.

Governance is hybrid: the reserve is formally managed by the municipality of Borgorose, but operational activities rely on staff from the Lazio Region. Funding comes mainly from regional transfers incorporated into the municipal budget. The reserve collaborates regularly with other protected areas (e.g., Sirente-Velino, Simbruini, Navegna-Cervia) and with institutions like the Carabinieri Forestali. Citizen associations are less systematically involved, though ad hoc collaborations occur. The CNP has fostered cooperation between reserves and municipalities, creating a sense of shared identity and practical collaboration.

SECTION C – Adequacy: Inputs and Processes

Resources are limited: staff numbers are small, and budgets remain minimal. The reserve depends heavily on regional allocations, with little capacity to secure alternative funding. Volunteers and schools contribute to some activities, but the lack of permanent staff constrains operations.

Public participation is modest, though the reserve maintains relationships with schools in the Salto Valley and occasionally with communities beyond its borders. Environmental education projects, guided hikes, and ad hoc citizen reporting (e.g., sightings of wolves or bears) provide some level of engagement. Monitoring is carried out mostly through scientific projects, such as water quality studies on the Duchessa Lake. These are long-term initiatives where results are disseminated carefully, to avoid conflicts between stakeholders (e.g., herders, visitors, environmentalists).

SECTION D – Delivery: Outputs and Outcomes

The reserve has organized: environmental education activities with schools; monitoring of biodiversity and water resources; occasional guided excursions and public outreach; participation in regional projects, especially related to large carnivores and raptors. Events and outreach remain limited due to staff and budget constraints.

Despite its modest resources, the reserve plays a crucial role in preserving one of the richest areas of biodiversity in Lazio. Its high mountains, intact ecosystems, and emblematic species connect it closely with the wider Apennine conservation network. Socially, however, benefits are less visible. Many visitors come for day hikes and do not interact with local businesses, leading residents to underestimate actual tourism flows. Peaks of several hundred hikers per day have been recorded, but their economic impact remains limited.

Suggestions and Future Perspectives

The interview highlights several priorities: strengthening staff and financial resources to ensure long-term management; supporting traditional pastoralism to maintain open habitats and reduce fire risk; increasing cooperation with local businesses to better integrate tourism and community benefits; expanding citizen involvement in monitoring and environmental education. The reserve is described as a "visionary creation," established to protect a unique corner of the Apennines. Its challenge today is to reconcile its ecological richness with the need to provide tangible social and economic benefits for local communities.

Parco Nazionale Gran Sasso e Monti della Laga

SECTION A – General Information

The Gran Sasso and Monti della Laga National Park is one of the largest protected areas in Italy, covering about 150,000 hectares across three regions—Abruzzo, Lazio, and Marche—and 44 municipalities. Its scale and complexity make it both a biodiversity hotspot and one of the most anthropized national parks, with numerous urban centers inside its boundaries. The park includes iconic landscapes such as the Gran Sasso massif, Campo Imperatore plateau, and the Monti della Laga chain. It is rich in flora and fauna, including wolves, golden eagles, and reintroduced populations of the Abruzzo chamois. The park also hosts unique endemic plant species documented in its floristic center at Barisciano.

SECTION B – Design: Context and Planning

The park combines extraordinary natural wealth with significant socio-economic challenges. On one side, it preserves ecosystems of international importance; on the other, it struggles with: depopulation of mountain villages, especially in the Teramo area; tourism pressure, particularly in areas like Campo

Imperatore, where unregulated flows cause environmental and management difficulties; conflicting perceptions, with some communities viewing the park as a constraint on development, especially after cuts to state subsidies and post-earthquake recovery delays; political tensions, such as disputes over ski resort modernization and the construction of new lifts and pistes, restricted by national and EU laws. The park's large size makes it hard to manage uniformly: the Aquila side has benefited from successful heritage-driven regeneration (e.g., Santo Stefano di Sessanio), while the Teramo side has faced stagnation after earthquakes and lack of investment.

The park has long relied on innovative approaches, including the creation of 11 "environmental-cultural districts", which expanded collaboration beyond its formal boundaries. These districts connected the park with nearby towns, heritage sites, and external stakeholders, creating synergies that once brought significant investment and visibility. Today, planning relies heavily on project-based funding, particularly EU LIFE programs, since ordinary state funding mainly covers staff salaries and utilities. Partnerships with other Apennine parks (Abruzzo, Majella, Sibillini) and cross-border collaborations are essential.

SECTION C – Adequacy: Inputs and Processes

Despite its size and responsibilities, the park suffers from severe staff shortages. From around 65–70 employees in the past, staffing has dropped to just over 30, following retirements and lack of replacements. This makes it difficult to maintain trails, infrastructure, and effective surveillance. Financially, the park depends on ministerial transfers for running costs, while most conservation and development actions are funded through external projects (LIFE, POR-FESR, cross-border initiatives).

Decision-making is slowed by bureaucratic oversight from the Ministry of the Environment. Unlike smaller regional parks, which can act quickly, the Gran Sasso park struggles with heavy procedures and fragmented responsibilities. A major problem has been the loss of the Forest Service, whose integration into the Carabinieri reduced flexibility and effectiveness in surveillance, fire prevention, and anti-poaching activities. This has led to weaker territorial control and frequent complaints from citizens. Despite these difficulties, the park has engaged with local communities through the European Charter for Sustainable Tourism (CETS), involving municipalities, associations, guides, and private businesses in joint projects. Still, citizen participation remains uneven, and relations with local populations are sometimes tense.

SECTION D – Delivery: Outputs and Outcomes

The park has achieved notable conservation results, including: reintroduction and growth of the Abruzzo chamois population (400–500 individuals); stable wolf populations (around 100 across 10 packs). Protection of golden eagles (7–8 nests, about a dozen individuals); habitat restoration and floristic research; LIFE projects to mitigate human–bear conflicts (bear-proof bins, fenced orchards, wildlife ramps); collaborations with CAI (Italian Alpine Club) on trail maintenance, although responsibilities are often misunderstood by the public. The CNP has fostered cooperation between regional and national parks, though the Gran Sasso park has sometimes struggled to match the efficiency and flexibility of smaller entities.

Environmentally, the park remains a stronghold of biodiversity and landscape heritage. Socially, results are mixed: while some towns (e.g., Santo Stefano di Sessanio) have experienced revitalization, others—particularly in the Teramo area—suffer from stagnation, depopulation, and limited tourism benefits. The park is often perceived as both a guardian of nature and a bureaucratic constraint, leading to ambivalent attitudes among local communities.

Suggestions and Future Perspectives

The interview emphasizes several priorities: reinforcing staff and surveillance capacity, especially after the loss of the Forest Service; improving communication with local communities to overcome mistrust and the perception of the park as an obstacle; continuing cross-park and cross-border collaborations to strengthen ecological connectivity; expanding sustainable tourism initiatives under the European Charter framework, ensuring benefits reach all territories, not just a few; addressing depopulation by linking conservation with incentives for local development and services. The Gran Sasso and Monti della Laga National Park embodies both the richness and contradictions of Italy's protected areas: immense biodiversity and landscape value, but also strong socio-political challenges. Its future depends on reconciling ecological stewardship with sustainable development for its many communities.