The uneven benefits of conservation. A spatial analysis of how different protection regimes influence local development in Polish municipalities

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THE UNEVEN BENEFITS OF CONSERVATION: A SPATIAL ANALYSIS OF HOW DIFFERENT PROTECTION REGIMES INFLUENCE LOCAL DEVELOPMENT IN POLISH MUNICIPALITIES

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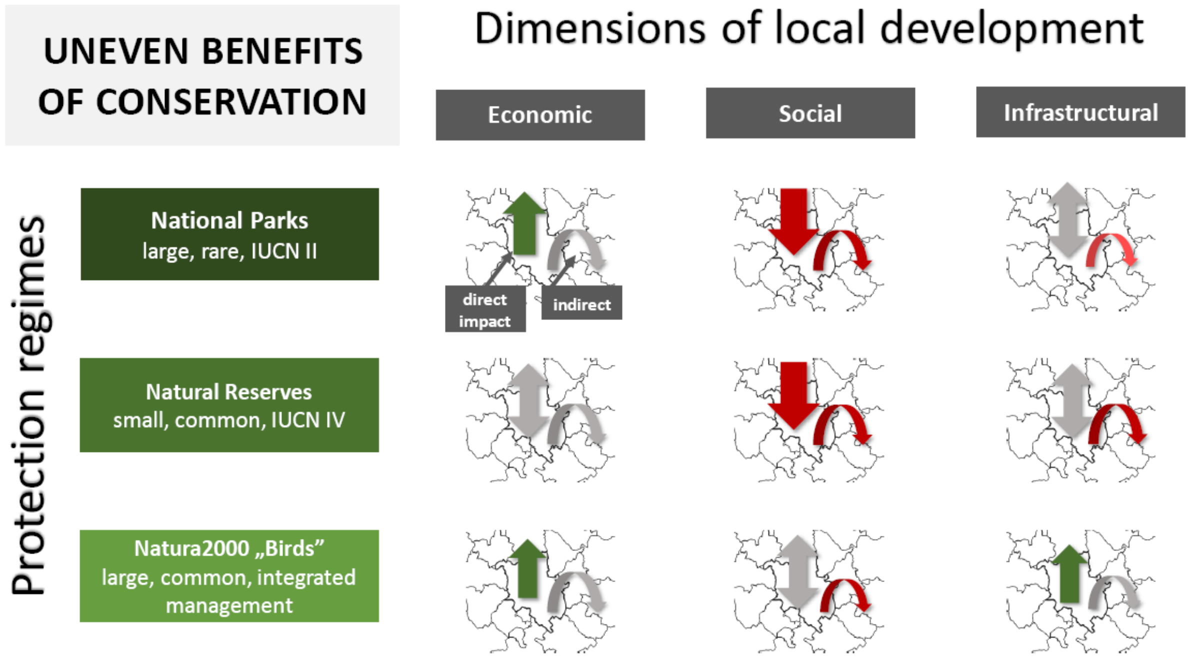
ABSTRACT

The balance between environmental protection and socioeconomic development is a critical policy challenge. Conservation efforts may constrain local development but can also generate benefits beyond nature protection itself, with effects varying across protection regimes and spatial scales. Poland presents a compelling case to examine this trade-off, given its rapid economic growth and significant expansion of PAs in recent decades. This study assesses the relationship between nature protection regimes and local development across Polish municipalities from 2009 to 2022. Using spatial econometric modelling (Spatial Durbin Error Model), we analyse the direct and indirect effects of national parks, nature reserves, and Natura 2000 sites on three dimensions of local development: economic, social, and infrastructural. The most consistent positive effects are observed for economic development in municipalities with high share of national parks and Natura 2000 sites. The effects on infrastructure development are limited: only Natura 2000 sites show a positive direct effect, while negative indirect effects suggest regional competition for investment. The social impacts of protection are predominantly negative, especially for stricter protection regimes. Moreover, these effects extend beyond administrative boundaries, likely due to interlinked labour markets. These findings challenge the notion that conservation uniformly hinders economic development. Instead, they suggest that outcomes differ depending on the protection regime, and that benefits are unevenly distributed – supporting local economic growth while reinforcing social exclusion. The study underscores the need for policies that mitigate social costs and promote more just and integrated development under expanding conservation efforts.

GRAPHICAL ABSTRACT



1. Introduction

Protected areas (PAs) are a dominant and well-established form of nature conservation in Europe and worldwide. Nonetheless, their functioning, as well as formation of new areas is often contested, with diverse socioeconomic impacts of area-based conservation being the conflicting issue (Maxwell et al., 2020; Gurney et al., 2023). A large part of the critical literature, especially within political ecology, addresses such conflicts through the lens of environmental justice – focusing on how environmental benefits and harms, rights and responsibilities are shared (distributive justice), whose values and knowledge systems are recognized (recognitional justice), and who is included in decision-making (procedural justice) (Bontempi et al., 2023; Strzelecka et al., 2021). These studies typically center on cases from the Global South, where the establishment of PAs has sometimes led to forced evictions and human rights violations, disproportionately affecting marginalized groups (Brockington & Igoe, 2006; Busscher et al., 2018).

In this article, however, we focus not on the environmental justice tradition, but on a different body of literature, concerned with quantification of the trade-off between nature protection and local development, particularly in the context of the Global North. In such settings, nature protection comes with limitations to at least some forms of land use, raising threats regarding incomes, jobs or industrial and infrastructural investment possibilities for local businesses and communities. At the same time, it may enable alternative development paths, most notably in tourism and recreation, with the overall impact on local development ambiguous and contingent on diverse institutional factors (Kauano et al., 2020; Hjerpe et al., 2022; Auliz-Ortiz et al., 2023; Mouillot et al., 2024). Among such factors, one should highlight the protection regime and the corresponding constraints on human activity. For instance, according to the authors of an extensive meta-analysis on this topic, (...) *socioeconomic benefits were more likely to arise when PAs were managed to promote sustainable resource use rather than enforcing stricter protection of biological resources* (Oldekop et al., 2015). Our inquiry thus aligns with the literature on institutional fit, which focuses on how well environmental governance arrangements correspond to the ecological and socioeconomic characteristics of the systems they aim to manage (Folke et al., 2007; Siltanen et al., 2022). From this perspective, the impact of nature protection on local development depends not only on the spatial scale of protection, but also on the extent to which conservation instruments are adapted to local capacities and development trajectories.

The potential trade-offs between the goals of conservation and socio-economic development are also variegated when it comes to the particular dimension of the latter process, as well as to the affected sectors of society. Change in the aggregate output or monetary income may have diverse distributional effects, which makes it relevant to analyse variables beyond mere product growth, such as jobs, entrepreneurship, poverty rates, access to utilities or other public services. Such a broad view, coming close to the notion of ‘a good life for all’ is visible in contemporary debates on conservation and biodiversity protection policies (Díaz et al., 2015).

In the transition economies in Central and Eastern Europe, the recent decades have been a period of both dynamic modernization and economic growth, as well as the expansion of the network of PAs in line with the European Union requirements of Natura 2000. These processes may have been to some extent contradictory with each other, as indicated by recurring social tensions. It has been evidenced in this context that the ‘Europeanization’ of nature protection, coupled with unequal regional development, led at times to environmental conflicts and marginalization of rural communities (Kluvankova-Oravska et al., 2009; Petrova, 2016; Yakusheva, 2019; Farkas & Kovács, 2021; Strzelecka et al., 2021).

Poland, with its leading rate of economic growth and a large network of Natura 2000 areas, can be perceived as a glaring example and a good case to study possible trade-offs between area-based conservation and local development in transitioning countries (Głogowska et al., 2013; Warchalska-Troll, 2019). Recently, the policy debate has been ignited once again by the adoption of EU Nature Restoration Law, which aims to restore biodiversity in European land and sea areas (European Union, 2024), while in Summer 2024 the Polish government announced the introduction of an environmental subsidy to municipalities with diverse forms of nature protection (Polish Press Agency, 2024). In this turbulent context, we examine whether Polish localities with PAs lagged behind in socio-economic terms or if the existence of these areas enabled them to pursue an alternative path of development.

To shed more light on this contentious issue, we analyse the relationship between the existence of PAs and the dynamics of socioeconomic development on a local level in 2476 Polish municipalities in 2009-2022. For this purpose, we econometrically model the growth rates of three aggregate indices, each representing a different dimension of local development: economic, social, and infrastructural. We investigate the role of three diverse forms of nature protection separately, as measured by the share of national parks, nature reserves and Natura 2000 ‘Birds’ (SPA) areas in the total land area of municipalities. Finally, we utilize spatial econometrics to obtain a more comprehensive understanding of the spatial effects of PAs.

In the following section, we present the results of a literature review concerning the relationship between nature protection and socioeconomic development, with particular attention to how different forms of protection influence this relationship. Section 3 outlines the key characteristics of the study area and the methodological approach. In Section 4, we report the results of our empirical analysis, followed by conclusions presented in Section 5.

2. Literature review

2.1. Between nature protection and socioeconomic development

Traditionally, PAs sought to preserve ecosystems in their most natural state by restricting human activity in a specified area (Mose & Weixlbaumer, 2006), often sparking social conflicts (West et al., 2006). In the late twentieth century, the outlook on the function of PAs has shifted and the interests of the local stakeholders were integrated into the mission of PAs (Mose & Weixlbaumer, 2006; Mose, 2007; Roe, 2008; Du et al., 2015), as illustrated by changes in EU member states' protection policies in the 1990s, outlined by the Habitats Directive (Gibbs et al., 2007).

Nowadays, the question of whether the integrated conservation model can effectively meet both ecological and local community needs – or whether PAs ultimately hinder local socioeconomic development – remains a topic of heated debate. While the existence of potential trade-offs is central to these conflicts, and differing perceptions among various actors have been thoroughly explored (Stern, 2008; Warchalska-Troll, 2019), in the Polish context, a number of conflict-generating mechanisms were observed during the implementation of the Natura 2000 network (Grodzińska-Jurczak & Cent, 2011; Grodzińska-Jurczak et al., 2012; Strzelecka et al., 2021). Early studies of stakeholders' perceptions revealed a rather ambivalent view of Natura 2000 areas. Two recurring findings were that such areas were seen as a barrier to investment – primarily due to protracted planning procedures and associated administrative costs (Głogowska et al., 2013; Cieślak et al., 2015; Dziemianowicz et al., 2015; Gutowska, 2015), and as a limitation on economic opportunities, especially for private landowners whose properties were included in protected zones (Strzelecka et al., 2021). Among the contributing factors were insufficient funding and information to support implementation, as well as a lack of flexibility and public participation in a largely top-down decision-making process (Dziemianowicz et al., 2015). These negative perceptions underscore the need for empirical assessment of the actual impacts of PAs on local development, as well as for positioning the Polish case within the growing body of quantitative research exploring similar dynamics in other spatial contexts.

Several European studies showed the positive impact of PAs on the indicators of local economic development, such as the gross income of municipalities or their investment spending (Cieślak et al., 2015; Zawilińska et al., 2021). At a more disaggregated level, the recent global meta-analysis of 30 studies (Kandel et al., 2022) found a significant and positive effect of PAs on household income levels, especially in the Global South, though of a low magnitude.

In the context of social development, one frequently studied issue is poverty reduction. A correlation has been established between PAs and high poverty, which may stem from the fact that PAs are often located in poorer regions from the outset (Andam et al., 2010; Vilela et al., 2022). However, Mammides (2020) having analysed data from 11 countries across the globe, found no conclusive evidence that administrative regions containing PAs experience worse poverty outcomes. In fact, some studies have identified a poverty-reducing effect of PAs in the Global South (Canavire-Bacarreza & Hanauer, 2013; Vilela et al., 2022), despite the lower base level of economic development in the municipalities adjacent to such areas.

In terms of jobs, the debate revolves around the question whether benefits from tourism development can compensate for the limited possibilities of resource extraction and processing. Some European cases noted the tourism development in municipalities with PAs (Zawilińska et al., 2021), but it does not necessarily result in more employment in tourism (Lundmark et al., 2010; Cremer-Schulte & Dissart, 2015). The overall effect of PAs on employment was reported as either positive (Sims et al., 2019), negative (D'Alberto et al., 2023) or negligible (Cremer-Schulte & Dissart, 2015) in different locations and by different metrics.

The impact of PAs on the development and access to public infrastructure is less often explored. Cieślak et al. (2015) noted a steady increase in water supply and sewerage infrastructure in Polish municipalities with PAs (N2000), although this progress was not sufficient to close the gap with the national average.

Despite growing interest in the topic, a significant knowledge gap remains regarding the impact of PAs on the development of public infrastructure, as well as on the economic and social dimensions of development – particularly in high-income countries (Bonet-García et al., 2015). Much of the existing research is based on single case studies, even though PAs consistently exhibit substantial variation across sites (Robalino & Villalobos, 2015). In more representative national or interregional assessments, the methodological approaches often rely on descriptive statistics (e.g. for Poland: Cieślak et al., 2015; Dziemianowicz et al., 2015; Zawilińska et al., 2021), rather than regression-based models (Sims, 2010; Kauano et al., 2020), quasi-experimental designs (Mammides, 2020; Vilela et al., 2022), or matching techniques (Auliz-Ortiz et al., 2023), which limits the ability to draw robust causal inferences. Moreover, most studies do not adequately account for the non-random placement of PAs (Sims, 2010), meaning that observed outcomes may reflect underlying natural amenities rather than the effects of protection measures themselves.

With many studies focusing on an isolated aspect of socioeconomic development, such as poverty, wages or employment (Lundmark et al., 2010; Canavire-Bacarreza & Hanauer, 2013; Robalino & Vilanos, 2015), there is a need for a more integrated approach. A key strength of this study is the use of three outcome variables, representing the economic, social, and infrastructural dimensions, to provide a more comprehensive assessment of local development. This integrated approach, supported by spatial econometric analysis, enables us to more effectively identify potential trade-offs and complementarities.

2.2. Forms of nature protection areas and their diversified impacts

The idea of area-based conservation in practice takes diverse forms, which differ in terms of the extent of nature protection, facilitating human activities, or the size of the PA. In line with the IUCN categorization, different forms of nature protection serve different objectives in terms of the environment and biodiversity conservation with diverse implications for local communities and socioeconomic development (Locke & Dearden, 2005; Maxwell et al., 2020; Gurney et al., 2023). The categories range from strict nature reserves and wilderness areas (with very restricted human presence and activity), through national parks and habitat management areas (where protection is combined with recreation and some interventions), to protected landscapes or managed resources (Dudley, 2008). Some authors argue that only IUCN categories I‒IV do actually perform the function of protection, while in categories V-VI the allowed human activity is so extensive that such areas should be renamed as sustainable development areas (Locke & Dearden, 2005; Oldekop et al., 2015).

The diversity of protection regimes suggests that their effects on local development are unlikely to be uniform; nevertheless, these differentiated impacts remain insufficiently studied. Oldekop et al. (2015) in their meta-analysis identified a potentially beneficial impact of protection on socioeconomic outcomes in the so-called “sustainable use” forms of protection (IUCN categories V and VI, as well as biosphere reserves). Conversely, stricter protection regimes (IUCN I-IV, such as nature reserves or national parks) appeared to have no discernible effect on development. According to these authors, synergies benefiting both conservation and socioeconomic outcomes are more likely under intermediate or integrative protection models, in which making use of PA’s social development opportunities (as opposed to a strict protection approach) leads to bringing about higher conservation effectiveness.

This relation is however not unambiguous, which suggests that certain economic and geographical factors may moderate the analysed relation. For instance, in the Mexican context, the PAs of diverse protection restrictiveness were accompanied with similar rates of social marginalization and deforestation, however more restrictive protection regimes aggravated development limitations of already peripheral areas (Auliz-Ortiz et al., 2023). In the Brazilian Amazon, strict protection was associated with a reduction of industrial production, with no adverse impacts on activity in other economic sectors (Kauano et al., 2020). Conversely, in a number of detailed country-level studies, national parks are found to have the most positive impact on economic activity and reduction of poverty rates, due to their potential to attract tourists (Reinius & Fredman, 2007; Sims, 2010; Buongiorno & Intini, 2021).

In the European context, the network of Natura 2000 areas is a specific and relatively young form of area-based conservation. Introduced in the 1990’s on the basis of Habitats Directive and Birds Directive, it covered in 2023 ca. 18% of the European Union's lands. Natura 2000 sites differ substantially in terms of the actual form and extent of protection, which is determined locally, according to the conservation needs and socioeconomic context. Nonetheless, Natura 2000 designations put certain restrictions on local planning, investment decisions and production processes. As such, the implementation of national Natura 2000 networks was perceived as a threat to local socioeconomic development in some European societies, including the Polish one (Grodzińska-Jurczak & Cent, 2011; Grodzińska-Jurczak et al., 2012; Blicharska et al., 2016; Strzelecka et al., 2021).

The economic research conducted so far, among them studies for Poland, suggests that these fears were not substantiated and that no negative impact on aggregate local investment, employment and production has been detected (Gantioler et al., 2014; Cieślak et al., 2015; Dziemianowicz et al., 2015; Gutowska, 2015). Conversely, the designation of Natura 2000 created new tourism and recreation possibilities for the regions, except for the areas with very high conservation requirements (Cruz et al., 2011; Warchalska-Troll, 2018), and was also correlated with an increase in EU public funds allocated to municipal budgets (Dziemianowicz et al., 2015). Likewise, they generated multiple benefits for local communities in terms of the provision of ecosystem services, such as water retention and regulation, air quality improvement and carbon storage. Their economic value may well exceed direct, market-related returns (Cruz et al., 2011; Gantioler et al., 2014; Schirpke et al., 2018).

Taking into account the presented body of literature, there still exists a research gap in terms of quantitative comparative analyses of the impacts of different forms of PAs on socioeconomic outcomes. This relates in particular to the juxtaposition of the newly founded European Natura 2000 areas against more traditional forms of nature reserves or national parks. To verify the hypothesis of the diversified impact of forms of protection, we include the three distinct types of Polish PAs that represent various models of environmental protection discussed and implemented globally: nature reserves (NR), national parks (NP) and Natura 2000 Special Protection Areas (SPA).[1]

3. Material and methods

3.1. Study area

We conduct the study on 2476 Polish municipalities (LAU, according to the EU Nomenclature of Territorial Units for Statistics), i.e. local administrative units that on average have 126 km^2, and a population of 15,300 people. Municipalities are the lowest tier in the local government system in Poland, therefore they enable careful consideration of local development processes, and its correlates. The relative fiscal autonomy of municipalities in Poland implies that their local characteristics, including the proportion of PAs, are crucial for determining their actual developmental trajectory.

The country's network of PAs was established largely during the post-socialist transition period in two subsequent waves. Firstly, the early 1990s saw the formation of multiple new national parks on top of the previously existing network. Eight national parks out of all 23 were founded between 1989 and 1996. In 2000, local authorities were given the capacity to veto such decisions, which has been the major obstacle for the expansion of this form of protection. As a result, currently only 0.6% of land cover remains strictly protected (IUCN I-II categories) in Poland, compared to 3.5% in the EU (Cazzolla Gatti et al., 2023). The second wave emerged after Poland's accession to the EU (2004-2012), when national Natura 2000 sites were designated. As already mentioned, these processes were accompanied by social tensions, where different parties referred to diverse sets of norms and values, but also to diverse preferences regarding the use of land. These conflicts are visible to this day, and the concerns about the economic future of local communities in the face of PAs expansion are the centre of antagonisms between the environmental movement and its opponents (Niedziałkowski et al., 2014; Strzelecka et al., 2021; Boćkowski et al., 2024).

The key characteristics of the three selected forms of PAs are explained in Table 1.

[1] Compared to Special Areas of Conservation (median = 0.0, SD = 22.45), the share of Special Protection Areas in a given municipality (median = 1.6, SD = 16.04) offers greater differentiation among low-value cases, lower dispersion, and a more informative distribution for further use in regression modeling.

Table 1. Forms of analysed PAs and their characteristics

	Nature Reserves (NR)	National Parks (NP)	SPA N2000 (Birds Directive) (SPA)
Institutional arrangement	No institutional representation at the local level	Locally-based, staffed institution responsible for managing the park	No institutional representation at the local level
Protective regime (IUCN category)	Mostly IV: with a dedicated plan of protection of certain species / habitats. Only activities specified in the plan are allowed.	Mostly II: tourism and recreation, as well as some active protection and wood extraction allowed	Diverse, mostly IV and VI: also includes conservation through management intervention. Environmental impact assessment is required for economic activity, including investment and housing.
Size and prevalence	Common and small: Exist in 793 communes (out of 2476 in total), with the average size of 1.26% of total commune area.	Rare and large: Exist in 117 communes (out of 2476 in total), with average size of 17.16% of total commune area.	Common and large: Exist in 1508 communes (out of 2476 in total), with the average size of 14.87% of total commune area.

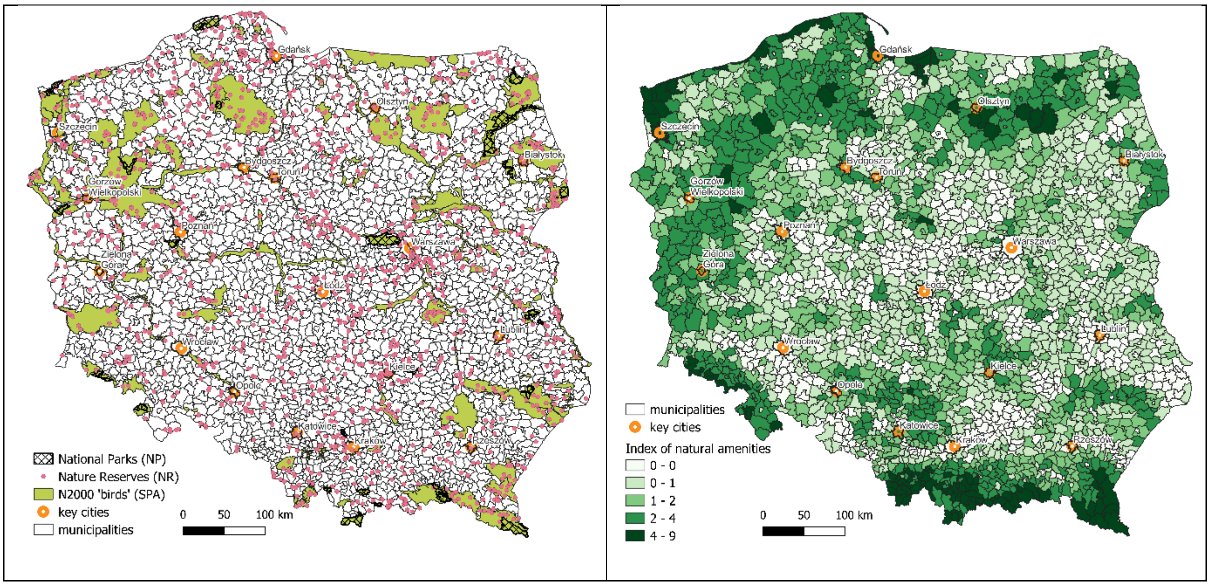
Source: own elaboration, based on (GUS BDL 2024).

The three types of PAs arguably represent distinct and sufficiently coherent regimes of nature protection. This applies in particular to nature reserves and national parks, which are relatively homogeneous in terms of their legal framework, institutional arrangements, and enforcement mechanisms, based on unified national regulations. Although Natura 2000 sites are more heterogeneous by design – given their focus on specific habitats and species – this variation operates within a clearly defined logic. While some management plans involve active restoration or impose more restrictive measures, the general principle remains the same across all sites: economic activities are permitted unless proven harmful to subjects of protection, based on the impact assessment procedure (Chmielewski & Głogowska, 2015).

The spatial distribution of three forms of PAs is presented on Figure 2a. NRs are the most dispersed, yet they tend to cover only a small share of a given municipality. On the contrary, SPAs constitute large areas, concentrated mostly in Northern and Eastern Poland. The NPs, in turn, are most prevalent in mountainous areas in the South, on the Baltic coast in the North, and in the North-Eastern part of the country. Clearly, an overlap is visible between the location of large PAs and the index of natural amenities – as shown on the Figure 2b. It serves as a reminder that the potential non-random placement of PAs should be taken into account when examining its effects on local development (Sims 2010).

Figure 1. Spatial distribution of Protected Areas (a) and of the Index of natural amenities (b)

Figure 1a.	Figure 1b.



Source: own elaboration, based on (GDOŚ 2024, GUS BDL 2024)

3.2. Sources and description of data

We use three aggregate indices as dependent variables to assess the impacts of PAs on key dimensions of local development: economic development (ECON), social inclusion (SOCI), and environmental infrastructure (INFR). Each index is composed of two complementary indicators that reflect core aspects of the respective development dimension. This approach allows us to capture a fuller picture of local-level change, avoiding biases stemming from reliance on single variables. The domain-specific indices for the baseline and final years were constructed as the sum of standardized component variables, using z-score normalization.[2] The dependent variable (ΔECON, ΔSOCI, and ΔINFR, respectively) in each case reflects the change in the value of the respective index over the study period, capturing the net dynamic in economic, social, or infrastructural development.

The economic development index (ECON) includes: (1) the municipal's own revenues per capita and (2) the number of business entities registered per 1,000 inhabitants. Municipal own revenues comprise local shares in personal income tax, corporate income tax, property tax, agricultural tax, and other revenues linked to the economic activity of local households and businesses. As such, this measure is a widely used proxy for the scale of local economies in the absence of GDP calculations at the municipal level (Biedka et al., 2022; Rok & Herbst, 2023). The number of business entities complements this by capturing entrepreneurial activity and economic density, thus broadening the understanding of local economic dynamics beyond fiscal measures (Śleszyński 2017). The social inclusion index (SOCI) consists of: (1) the unemployment rate and (2) social assistance beneficiaries below the income threshold[3], as a percentage of the total population. The unemployment rate is a long-standing indicator of social exclusion, pointing to the inability of individuals to fully participate in the social and economic life of their communities. The social assistance beneficiaries measure adds a complementary perspective, reflecting income-based scale of poverty in a community. Together, these two variables capture key dimensions of contemporary measures of social deprivation (Ministry of Housing, Communities & Local Government, 2019). Finally, the environmental infrastructure index (INFR) comprises: (1) the share of population with access to a sewage network, and (2) capital investment expenditures from municipal budgets on environmental protection infrastructure per capita. The former

[2] Z-score normalization involves subtracting the mean from the value of a given indicator and dividing the result by its standard deviation. This method is widely used in composite index construction and is particularly suitable when the dataset contains extreme values, as it reduces their influence without excluding them (OECD, 2008).

[3] In 2022 the net income threshold for a single-person household equaled 776 PLN per month.

is a widely used indicator of access to essential environmental services, and a fundamental public good under municipal jurisdiction. Following Poland's accession to the EU, the development of sewage infrastructure has been significantly supported through competitive EU funds (Piasecki, 2019). Investment in environmental infrastructure[4] broadens the scope, allowing us to assess the degree to which municipalities have actively committed resources to various environmental improvements. Given the valuable natural assets associated with PAs, we expect that municipalities with larger shares of PAs may have had greater motivation as well as financial opportunities to improve environmental infrastructure.

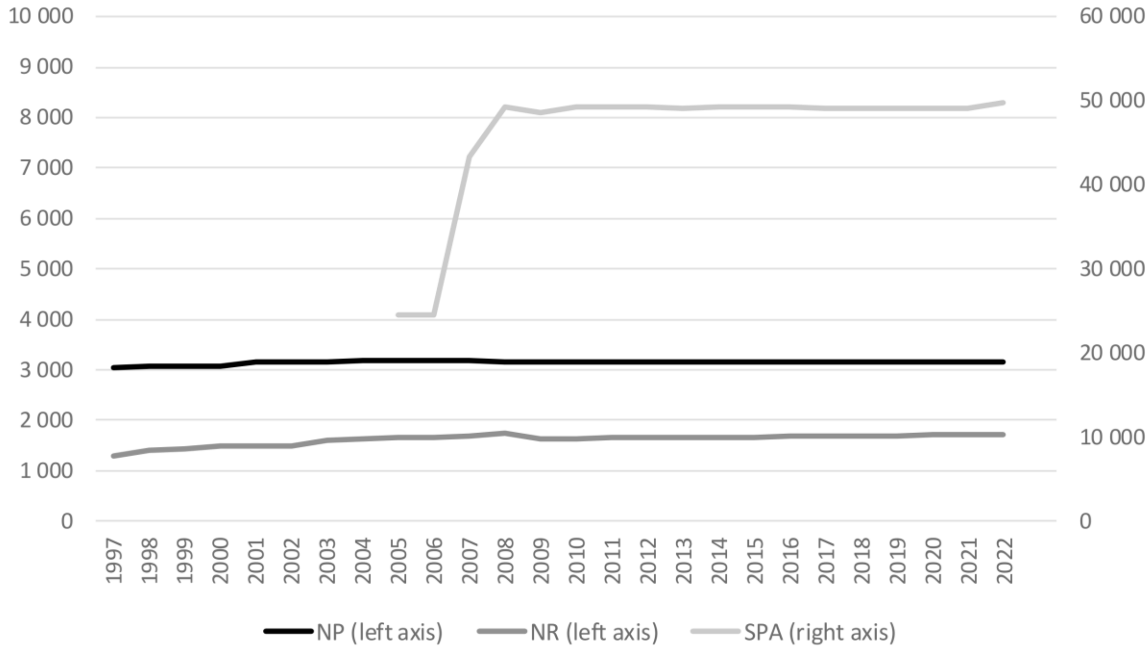
For all dependent variables we apply a consistent time frame, covering the period from 2009 to 2022.[5] The period in focus is characterized by an almost absolute freeze in the creation or enlargement of new PAs in Poland (see: Figure 2). Comparing two consecutive periods of 14 years (1996-2009 and 2009-2022), the rate of growth of the total area covered by a given type of PAs was significantly reduced; in the case of NPs the rate fell from 4.5% between 1996 and 2009, to 0.2% in the later period, whereas in the case of NR it fell from 27.7% to 4.9% (GUS BDL 2024). The starkest change was observed in the case of Natura 2000. Here, the whole network of PAs has been created from scratch, beginning in 2004. Between 2004 and 2009 the Natura 2000 network emerged to cover 18% of the land area in Poland. Over the next 14 years, there were only minor adjustments, with the area of both SAC and SPA growing by roughly 2.5%. The explanatory variables consist of three indicators depicting the area covered by a given type of PA, i.e. NP, NR and SPA, in 2022.[6]Although we do not account for site-specific qualitative differences stemming e.g. from local management plans and implementation processes, using the three categories of PAs in this study, given their relatively limited within-category variation, allow us to capture the main institutional and functional contrasts. In this sense, the surface-based operationalization offers a reasonable and scalable proxy for the dominant protection logic in each regime, enabling consistent comparison across a large number of municipalities.

[4] The official name of this budget category is environmental protection and public utilities, and it covers wastewater and waste management, street cleaning, maintenance of green spaces, air and climate protection, animal shelter operations, and public lighting infrastructure.

[5] To address the volatility of (1) municipal own revenues, and (2) capital investment expenditures on environmental protection infrastructure, we calculate its values as an average over a three-year period centered around the target year.

[6] Optimally, the 2009 data should be used here, to represent the impact of the baseline level of PAs for subsequent changes in measures of local development. However, due to the data constraints, we use the current (2022) data. It may be justified on the grounds of the almost complete halt of the establishment of new PAs or enlargement of the already existing ones, over the 2009-2022 period.

Figure 2. Total area covered by NP, NR and SPA in Poland, 1996-2022 [sq. km]



Source: GUS BDL 2024

A potential concern in assessing the impact of PAs on local development is the issue of endogeneity – particularly reverse causality (where protection regimes are established in response to factors also influencing socioeconomic outcomes) or omitted variables that simultaneously affect both PA designation and subsequent development (Mouillot et al., 2024). In the Polish context, however, the risk of such endogeneity is arguably limited due to the historical and institutional background of nature protection. Most national parks were established in the 20th century, with the most recent one designated in 2001. As a result, any potential selection bias related to their placement is likely to have stabilized well before the beginning of our study period in 2009. In the case of Natura 2000 areas, the top-down nature of the designation process further reduces concerns about endogenous placement. The planning and implementation were largely driven by scientific, conservationist, and environmental organizations' interests, rather than local socioeconomic conditions (Grodzińska-Jurczak & Cent, 2011; Grodzińska-Jurczak et al., 2012). Early empirical studies support this view, showing only weak – and generally positive – correlations between the presence of Natura 2000 sites and tourism potential or local economic indicators such as income and employment levels (Stanny, 2010; Cieślak et al., 2015; Gutowska, 2015; Dziemianowicz et al., 2015).

To further mitigate risks of endogeneity and omitted variable bias, our analysis focuses on the dynamics of change over the 2009–2022 period, rather than on absolute levels of development. We include the baseline values of the dependent variables as control variables, thereby accounting for pre-existing differences across municipalities that may shape their development trajectories. Specifically, we add 2009 values for the social (SOCI_09), economic (ECON_09), and infrastructural (INFR_09) indices of local development to control for initial conditions affecting subsequent change. We also include control variables that address key structural and spatial factors. First, peripherality (PERI) is measured as the distance from the municipality to the regional capital (voivodeship seat). Given the spatial concentration of development processes, peripheral areas often face economic disadvantages, depopulation, and limited endogenous growth potential (Smętkowski, 2018). Second, municipality type (TYPE) captures the urban–rural divide, which remains a critical factor in shaping local development trajectories. We distinguish between three categories: urban municipalities (larger towns and cities), mixed municipalities (a small town with its hinterland), and rural municipalities (the least urbanized). Finally, to address the non-random placement of PAs, we include an aggregate natural amenities index (AMNI).

PAs tend to be located in areas of high landscape and ecological value – features that are also known to attract tourism (Backman et al., 1991), and drive in-migration (McGranahan, 2008; Waltert et al., 2011). Failing to control for these factors could lead to an overestimation of the effects of PAs on development outcomes (Sims, 2010; Andam et al., 2013). To account for this, our index combines data on forest cover, elevation, presence of inland water bodies, and access to the seacoast.[7]

All variables used in the analysis are listed in Table 2.

Table 2. The variables used in the study

Statistic	Description	Year	N	Mean	SD	Min	Max
Dependent variables (components of composite indices)							
ECON: component variable 1	Municipal own revenues, annual average, PLN per capita	2008-10	2476	1085.5	952.6	282.8	35127.7
		2021-23	2476	2529.6	1357.1	838.9	40701.9
ECON: component variable 2	Number of business entities registered, per 1,000 inhabitants	2009	2476	705.1	315.1	262.0	3818.0
		2022	2476	986.0	374.3	338.0	9005.0
INFR: component variable 1	Capital investment expenditures from municipal budgets on environmental protection infrastructure, annual average, PLN per capita	2008-10	2476	105.9	185.2	0	3538.5
		2021-23	2476	226.5	300.4	0	5941.1
INFR: component variable 2	The share of population with access to sewage networks, percentage of the total population	2009	2476	40.63	30.57	0	100
		2023	2476	55.81	30.41	0	100
SOCI: component variable 1	Unemployment rate, percentage	2009	2476	9.232	3.939	1.7	28.4
		2023	2476	4.526	2.431	0.5	17.2
SOCI: component variable 2	Social assistance beneficiaries below the income threshold, percentage of the total population	2009	2476	8.790	5.758	0	15.3
		2023	2476	2.998	1.904	0	15.3
Explanatory variables							
NP	The percentage of the municipality's area covered by the NP	2022	2476	0.811	5.393	0	85.9
NR	The percentage of the municipality's area covered by the NR	2022	2476	0.403	1.305	0	21.2
SPA	The percentage of the municipality's area covered by the SPA	2022	2476	9.059	16.038	0	100
Control variables							
ECON_09	Value of the ECON index in the baseline year	2009	2476	0	1.730	-2.113	35.7
INFR_09	Value of the INFR index in the baseline year	2009	2476	0	1.471	-1.901	20.16
SOCI_09	Value of the SOCI index in the baseline year & multiplied by [-1]	2009	2476	0	1.767	-10.24	3.188

[7] The index is calculated as the sum of ranks of four landscape-related variables, i.e. (1) percentage of the municipality's area covered by forests, weight: 1; (2) percentage of the municipality's area covered by inland waters, weight: 1; (3) average altitude above sea level in the municipality, weight: 1; (4) share of sea coast land strip 1km wide within the municipality's area, weight: 2. For each variable a rank of 0-3 was ascribed based on the following criteria: variable (1) – 4 classes based on Jenks natural break optimization , variable (2) – 5 classes based on Jenks natural break optimization, and top 2 classes merged into one, variable (3) - 10 classes based on Jenks natural break optimization, and low 7 classes merged into one, variable (4) – zero as the lowest class, and the remaining three classes based on the equal count criterion.

PERI	Distance from the municipality's centroid to the voivodeship seat, in km	2022	2476	60.744	29.92	0	179
AMNI	Index of natural amenities in municipalities	2022	2476	1.631	1.501	0	9
TYPE:RURAL	Dummy variable for rural municipalities	2022	2476	0.611			
TYPE:URBAN	Dummy variable for urban municipalities	2022	2476	0.122			
TYPE:MIXED	Dummy variable for mixed municipalities	2022	2476	0.267			

All data used in the analysis was obtained from open public sources. Socio-economic data for municipalities was obtained from (GUS BDL 20205). Data for PAs was obtained from (GDOŚ 2024). Spatial datasets for municipalities and for PAs were elaborated and merged using the Quantum GIS software. In the first step, we attributed the socio-economic database to a spatial set of municipality polygons. In the second step, we intersected the map of the municipality's boundaries with the maps of different PAs to calculate the proportion of each PA type in each municipality. Finally, a full spatial database was created and analysed using the R software, and the following packages: spdep, sf, ggplot2, stargazer, spatialreg.

3.3. Methodological approach

Typically, the Ordinary Least Squares (OLS) linear estimation would be applied to investigate the determinants of a given dependent variable, but such a model is based on the assumption of unrelated and homoscedastic error terms. Using the spatially disaggregated data often entails spatial autocorrelation, which compromises the robustness of OLS estimations (Anselin 2022). As Tobler's Law reminds us, things that are close to one another are likely to be more similar than things that are further apart (Tobler 2004).

In order to verify the spatial autocorrelation in our data, we need to construct the spatial weights matrix. We use the row-standardized second-order queen contiguity criterion, inclusive of lower orders. Hence, we assume spatial interdependence not only among a given municipality and its neighbours, but also include the first-tier 'neighbours of my neighbours' – to account for urban municipalities that are fully contained within one rural municipality. The mean number of neighbours in the resulting matrix is 18.9 (2 ÷ 43). As LeSage (2014) suggests the determination of a spatial weight matrix is somewhat arbitrary, yet the empirical findings indicate that if a model itself is adequately specified, its sensitivity to selection of a different matrix is negligible.

Following the well-established approach (Kauano et al. 2020), we begin the model specification with a non-spatial OLS regression model as a benchmark, and then test the possibility of extending the baseline model to account for the spatial interaction effects. We start our estimations with a spatially-blind OLS model equation:

(1) $\mathrm{LD}_i = \beta_0 + \beta_1 PA_i + \beta_2 PERI_i + \beta_3 AMNI_i + \beta_4 LD_{it=0} + \beta 5 TYPE_i + \varepsilon_i$

where i refers to the i-th municipality, βn are the estimated coefficients of explanatory variables, and ε is the standard error term. LDi refers to local development, and is measured by one of the three dynamic variables: ΔECON, ΔSOCI and ΔINFR, depending on a model. PAi is the explanatory variable, measured by NP, NR or SPA, depending on the model. Control variables include the measure of peripherality PERI, the measure of natural amenities AMNI, $LD_{it=0}$ refers to the baseline values of the three local development dimensions (ECON09, SOCI09, INFR09) and TYPE dummy, which checks the type of municipality – with URBAN municipalities being a reference category for RURAL and MIXED municipalities.

Subsequently, we assess the spatial dependence of the residuals of the fitted OLS regressions using a set of Lagrange Multiplier (LM) tests, applying the same row-standardized second-order queen contiguity criterion for the spatial weight matrix as described above. The Lagrange Multiplier diagnostics facilitate the distinction between two different sources of spatial dependence. The first one is spatial diffusion, which occurs when proximate units are influenced by their neighbours, and vice versa. To account for this type of spatial dependence, spatial lag models (SLM) are constructed. The second source of spatial dependence is attributional dependence. Here, the similarity between neighbouring units reflects the fact that they share the same underlying processes, stemming from the fact of being geographically clustered. Direct interaction between different units does not play an important role in explaining this type of spatial dependence. Attributional dependence may be accounted for by using the spatial error model (SEM). If both types of spatial dependence are present in the data, more complex models might be constructed, including Spatial Durbin Error Model (SDEM)- for local autocorrelation, or Spatial Durbin Model (SDM) – for global autocorrelation, i.e. a situation where change in one region impacts not only its immediate neighbours, but spills over to all other regions in the dataset. We expect that in our case the spatial autocorrelation detected in the dependent variables is of an attributional nature and reflects the spatially clustered nature of development processes, as proposed by the New Economic Geography (Krugman 2011).

The results of Lagrange Multiplier tests are shown in Table 3. If both LM lag and LM error tests are significant, one should compare the results of the so-called Robust LM tests. Given that spatial dependency was detected in the data – as indicated by the low p-values of the LM tests - the assumption of independence among observations is not met, and the standard OLS estimations might be biased. To appropriately account for that issue, we apply spatial econometrics (LeSage 2014). In each of the nine model iterations, the Robust LM error tests return lower p–values than the Robust LM lag tests. Drawing on these results, the spatial dependence might be considered as attributional and should thus be accounted for by applying the SEM or more complex SDEM models. Such results fit well with the expected outcome. Therefore, empirical results corroborate the theoretical considerations, which – as stated by (Rüttenauer 2022) – should guide the model selection, either by ruling out some sources of spatial dependence by theory, or by guiding the choice of either global or local spillover effects.

Table 3. The results of Lagrange Multiplier tests

	ΔSOCI	*ΔECON*	*ΔINFR*
NP	LMerr = 470.64*** LMlag = 315.66*** **RLMerr = 164.42***** RLMlag = 9.439***	LMerr = 23.914*** LMlag = 12.44*** **RLMerr = 35.458***** RLMlag = 23.983***	LMerr = 12.211*** LMlag = 3.814* **RLMerr = 12.313***** RLMlag = 3.915**
NR	LMerr = 461.82*** LMlag = 322.31*** **RLMerr = 147.06***** RLMlag = 7.552***	LMerr = 19.497*** LMlag = 11.538*** **RLMerr = 28.899***** RLMlag = 20.939***	LMerr = 11.241*** LMlag = 3.711* **RLMerr = 10.812***** RLMlag = 3.282*
SPA	LMerr = 479.04*** LMlag = 319.66*** **RLMerr = 170.66***** RLMlag = 11.286***	LMerr = 18.755*** LMlag = 11.033*** **RLMerr = 26.798***** RLMlag = 19.076***	LMerr = 12.037*** LMlag = 3.721* **RLMerr = 12.245***** RLMlag = 3.929**
Model	SEM / SDEM	SEM / SDEM	SEM / SDEM

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Thus, the next stage in the analytical approach is fitting the nine SEM models that address the spatial dependence of error terms. The SEM equation is expressed as follows:

(2) $LD_i = \beta X_i + \lambda W\varepsilon + u$

Where $\lambda W\varepsilon$ is the spatially structured error, composed of the spatial error ε weighted by the autoregressive term λ, and by the W, i.e. the row-normalized coefficient derived from a spatial weight matrix described above. The term u denotes random error unexplained by the model, and X denotes independent variables described under equation (1).

The last stage is the estimation of nine SDEM models that address both the spatial dependence of the error terms, and the spatial lag of predictor variables. It is the most generalized version of the local spillover model, and is estimated as follows:

(3) $LD_i = \beta X_i + WX\theta + \lambda W\varepsilon + u$

where W is the row-normalized coefficient derived from a spatial weight matrix described above, X represents covariates described under equation (1), and the term θ denotes a vector of spatial spillover parameters, including a distinct spatial effect for each covariate. The term $\lambda W\varepsilon$ is the spatially structured error described under equation (2), u denotes random error unexplained by the model. The SDEM model comprises a spatial error term combined with spatially lagged covariates and is thus more complex than a single-source SEM model. To fully grasp the role of predictors in SDEM models, one should take into account the spatial spillover effect, i.e. the effect of a change in a given variable in the spatially weighted neighbouring localities on the dependent variable in the unit of interest (LeSage 2014).

In order to estimate the goodness of fit of the estimated models, and to verify if the SEM and SDEM models are nested, the Log likelihood is used. This measure allows a robust comparison of both OLS and spatial models. The potential heteroskedascity in the estimations is tested with the studentized Breusch-Pagan test, but given its sensitivity to a large sample size, we also rely on the visual inspection of the QQ plots and fitted residuals.

4. Results

In the first step, we calculated the nine OLS models, filling the matrix of three protection regimes (NP, NR, SPA) and three dimensions of local development (ΔECON, ΔSOCI and ΔINFR). Knowing that the underlying data exhibits a significant spatial autocorrelation, we may assume that these linear models suffer from limited robustness and thus we skip the comprehensive reporting of their results (the OLS model estimations are available in the Supplementary material). Subsequently, a set of nine SEM and nine SDEM models were calculated, following the equations (2) and (3), respectively. The Log Likelihood measure was used to compare the goodness of fit of the models, proving that SEM offered a significant improvement over analogous OLS models, and SDEM – over analogous SEM models (95% confidence threshold). Thus, the more complex SDEM models should be utilized as the most accurate estimation (the SEM model estimations are available in the Supplementary material). Finally, utilizing the Breusch-Pagan (BP) test, we find significant heteroskedascity in all our models, implying that p-values close to the significance threshold should be interpreted cautiously. On the other hand, the visual interpretation of QQ plots and fitted residuals, as well as the fact of using a relatively large sample, limits the risk of invalid inference of results. Nonetheless, to address the issue of heteroskedascity, we mainly focus on reporting regression coefficients significant at a relatively strict 0.01 threshold. Given the procedure described above, we further report key results of the nine SDEM models, presented in Table 4.

We start by looking at the regression coefficients of control variables in order to verify if the models yielded the expected results. Firstly, all three indicators of local development measured in the initial year prove to be strong and consistent predictors of a subsequent change. The poorer the initial level indicated by ECON_09, INFR_09, SOCI_09, the higher the reported rate of improvement in the said dimension.[8] This fits well with the earlier findings on economic convergence among regions of Central and Eastern Europe (Smętkowski & Wójcik 2012). In general, the base level of a given phenomenon proved to be the most significant predictor. The peripherality (PERI) is a significant and negative predictor of both economic and social development, indicating that more remote municipalities face persistent disadvantages in these dimensions. However, it does not have a statistically significant effect on infrastructural development. This may reflect the relatively strong focus on territorial cohesion within EU regional policy. At the same time, rural municipalities (as compared to urban ones) exhibit higher rates of improvement in the social and economic dimensions, lending support to the hypothesis of regional convergence in these domains. In contrast, the infrastructural development index shows an opposite tendency: both rural and mixed municipalities perform worse than their urban counterparts. This suggests that despite substantial investment efforts, urban municipalities maintain a structural advantage in terms of access to and modernization of public infrastructure. In line with well-established research findings (Waltert & Schläpfer 2010; Waltert et al. 2011), the high level of open space natural

[8] The negative sign of the SOCI_09 coefficients means that the "worse" (i.e. higher) the initial level of unemployment and poverty had been, the better outcome in terms of improvement in levels of said phenomena (indicated by ΔSOCI) was achieved.

amenities (AMNI) is a predictor of economic development. For the social dimension, natural amenities do not play a statistically significant role.

The most consistent positive effects of PAs are observed for the economic dimension of development (ΔECON), although the magnitude of these effects remains modest. The strongest economic impact is associated with national parks (NP), where each additional percentage point of municipal area under protection is linked to a 0.019 standard deviation increase in the ΔECON index. The direct effect of PAs on infrastructural development (ΔINFR) is statistically insignificant for both national parks and nature reserves; a small but statistically significant and positive effect is observed only for SPA areas. For the social dimension of development (ΔSOCI), the relationship is predominantly negative. Statistically significant negative effects are found for both national parks (−0.013) and nature reserves (−0.041). In practical terms, a 10% coverage by national park corresponds to worsening of the ΔSOCI index by 0.13 standard deviations and improving the ΔECON index by 0.19 standard deviations. Assuming equal contribution of index components, this would translate to a reduction in unemployment improvement by approximately 0.28 percentage points, and a reduction in the decline of social assistance coverage by about 0.40 percentage points. For the economic dimension, a 10% national park coverage corresponds to an increase of roughly 90 PLN in municipal revenues per capita and 30 additional business entities per 1,000 inhabitants. These figures reflect gains above or below the average pace of improvement observed across all municipalities during the study period.

The SDEM estimations allow us to look more broadly at the determinants of the local development processes, including the spatially lagged explanatory variables. Among these, the most consistent results relate to the positive impact of natural amenities located nearby on a given municipality's infrastructural and social development. We may hypothesize that it reflects the supralocal nature of the labour market opportunities and infrastructural development driven by the landscape's attractiveness. The indirect effect on the economic dimension is negligible, as the revenues are captured directly by the municipality that host such amenities. The lagged variables reflecting the initial levels of SOCI_09 and ECON_09 are also statistically significant, but with signs opposite to those of the corresponding direct effects. This suggests that socio-economic processes are diffusive, whereby development poles in neighbouring areas create positive spillovers that stimulate local growth.

Table 4. SDEM estimation results

Dependent var.	ΔINFR	ΔECON	ΔSOCI		ΔINFR	ΔECON	ΔSOCI		ΔINFR	ΔECON	ΔSOCI
Model no.	(1)	(2)	(3)		(4)	(5)	(6)		(7)	(8)	(9)
INFR_09	-0.526***				-0.526***				-0.529***		
	(0.018)				(0.018)				(0.018)		
ECON_09		-0.079***				-0.073***				-0.074***	
		(0.009)				(0.010)				(0.009)	
SOCI_09			-0.259***				-0.261***				-0.262***
			(0.014)				(0.014)				(0.014)
NP	**0.007**	**0.019*****	**-0.013*****	**NR**	**0.003**	**0.005**	**-0.041****	**SPA**	**0.004****	**0.003****	**-0.002**
	(0.004)	(0.002)	(0.004)		(0.018)	(0.010)	(0.016)		(0.002)	(0.001)	(0.001)
PERI	-0.001	-0.002**	-0.003***		-0.001	-0.002**	-0.003***		-0.001	-0.002**	-0.003***
	(0.001)	(0.000)	(0.001)		(0.001)	(0.001)	(0.001)		(0.001)	(0.001)	(0.001)
AMNI	0.044**	0.030**	0.020		0.048**	0.042***	0.019		0.026	0.030**	0.021
	(0.017)	(0.010)	(0.014)		(0.017)	(0.010)	(0.014)		(0.019)	(0.011)	(0.016)
RURAL	-0.568***	0.106*	0.229***		-0.566***	0.116*	0.228***		-0.584***	0.109*	0.219***
	(0.080)	(0.046)	(0.063)		(0.080)	(0.047)	(0.063)		(0.080)	(0.047)	(0.063)
MIXED	-0.221**	0.003	0.193**		-0.222**	0.003	0.202**		-0.239**	-0.005	0.203**
	(0.081)	(0.048)	(0.069)		(0.081)	(0.048)	(0.069)		(0.082)	(0.048)	(0.069)
lag.INFR_09	0.042				0.066				0.053		
	(0.062)				(0.060)				(0.062)		
lag.ECON_09		0.098***				0.095***				0.100***	
		(0.027)				(0.027)				(0.028)	
lag.SOCI_09			0.174***				0.128**				0.154***
			(0.038)				(0.040)				(0.039)
lag.NP	**-0.030***	**-0.010**	**-0.054****	**lag.NR**	**-0.212****	**-0.058**	**-0.305*****	**lag.SPA**	**-0.004**	**0.000**	**-0.020****
	(0.015)	(0.009)	(0.018)		(0.067)	(0.040)	(0.082)		(0.005)	(0.003)	(0.006)
lag.PERI	-0.001	0.003**	0.006**		-0.001	0.003**	0.006*		-0.001	0.003**	0.007**
	(0.002)	(0.001)	(0.002)		(0.002)	(0.001)	(0.002)		(0.002)	(0.001)	(0.002)
lag.AMNI	0.143***	-0.024	0.169***		0.143***	-0.029	0.171***		0.141**	-0.037	0.233***
	(0.043)	(0.024)	(0.049)		(0.041)	(0.024)	(0.049)		(0.047)	(0.027)	(0.055)
lag.RURAL	0.066	0.216	-0.160		0.154	0.243	-0.193		0.097	0.263	-0.285
	(0.306)	(0.183)	(0.305)		(0.302)	(0.183)	(0.306)		(0.308)	(0.185)	(0.306)
lag.MIXED	-0.192	0.377*	0.084		-0.155	0.390*	0.089		-0.154	0.390*	0.173
	(0.297)	(0.179)	(0.331)		(0.292)	(0.179)	(0.332)		(0.298)	(0.179)	(0.331)
Observations	2,476	2,476	2,476		2,476	2,476	2,476		2,476	2,476	2,476
Log Likelihood	-3,752.8	-2,415.7	-3,419.7		-3,750.9	-2,444.0	-3,420.3		-3,752.1	-2,441.5	-3,422.9
Lambda	0.130*	0.142*	0.519***		0.101^{+}	0.124*	0.524***		0.136*	0.130*	0.517***
BP test	82.65***	165.2***	382.2***		83.39***	91.33***	381.7***		85.27***	98.94***	396.0***
Note:	$^{+}$ $p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$										

Finally, we report the direct, indirect, and total effects of different types of PAs on the three dimensions of local development (Table 5). The results for social dimension reveal a consistent pattern of negative and statistically significant indirect impacts. These spillovers suggest that the adverse effects of stricter protection regimes are not limited to the municipalities that host them, but extend to neighbouring areas - likely due to the supra-local integration of labour markets (Marcińczak & Bartosiewicz, 2018). For the economic dimension, the indirect effects are negligible, confirming that there are no significant spatial spillovers in this respect. At the same time, it demonstrates that the positive effect of NP and SPA felt locally does not come at the expense of hindering the development of one's neighbours. Regarding infrastructural development, a consistent negative indirect effect is visible. This may point to redistributive competition over infrastructure investment, where limited regional resources (e.g. EU co-financing) are concentrated in PAs, possibly at the expense of nearby municipalities. In summary, the spatial effects of PAs are most pronounced and problematic in the social domain, where both direct and indirect impacts tend to be negative. For economic development, the impacts are largely localized and positive, while infrastructure-related effects appear more mixed, suggesting potential allocation tensions.

Table 5. Direct and indirect effects of PAs on local development – SDEM estimation

	Direct	*Indirect*	*Total*
***Δ*SOCI**			
NP	-0.013***	-0.054**	-0.067***
NR	-0.041**	-0.305***	-0.346***
SPA	-0.002	-0.020**	-0.021***
***Δ*ECON**			
NP	0.019**	-0.010	0.008
NR	0.005	-0.058	-0.053
SPA	0.003**	0.000	0.003
***Δ*INFR**			
NP	0.007	-0.030*	-0.024
NR	0.003	-0.212**	-0.209**
SPA	0.004**	-0.004	0.001
Note:	$^{+}$ $p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$		

5. Discussion and conclusions

Our research framework allowed us to examine the relationship between three regimes of nature protection and three dimensions of local development. The results, obtained for Polish municipalities over the period 2009–2022, suggest that this relationship is differentiated – something that was far from obvious – with spatial interaction playing a significant role in some of the observed effects. Overall, the presence of PAs in a municipality appears to support stronger local economic growth and increased business density. However, it also has a negative effect on social outcomes, as reflected in higher unemployment rates and greater reliance on social assistance. The improvement of environmental protection infrastructure – measured both by financial outlays of municipalities and expansion of a sewage network, was only weakly correlated with the size of PAs, showing positive direct effects for SPA areas and negative indirect effects for the other two types of PAs. In sum, the trade-off between nature protection and socioeconomic development is ambiguous and contingent on the type of protection regime, the specific development dimension, and the proximity to the protected area.

According to the estimations, there was a positive and statistically significant correlation between NP and SPA areas and the rate of economic development within a municipality. Therefore, claims that PAs hinder economic activity in general are not supported by our findings. However, the observed benefits in terms of local revenue and entrepreneurship are modest. The insignificance of spatial effects further suggests that these positive outcomes are not achieved at the expense of neighbouring municipalities, but rather stem from the mobilization of local resources. In other words, no trade-off between nature protection and local economic development was observed in Poland – an outcome that aligns with earlier assessments of the Natura 2000 network rollout (Gantioler et al., 2014; Cieślak et al., 2015; Gutowska, 2015). This conclusion applies to both business density and municipal revenues, implying that any restrictions on industrial activity, construction, or timber harvesting were, on average, offset by gains in other sectors of the local economy. These findings are consistent with previous analyses of the relationship between PAs and municipal revenues (Cieślak et al., 2015; Zawilińska et al., 2021), as well as with studies highlighting the role of national parks in fostering tourism and recreation in Poland (Czeszczewik et al., 2019; Zawilińska et al., 2021).

Conversely, the extent of both national parks and nature reserves was negatively correlated with the social dimension of local development, as measured by changes in unemployment rates and reliance on social assistance. This suggests that the economic structure of municipalities hosting these two types of PAs may be less conducive to stable employment. Combined with the earlier findings, this also indicates that the economic benefits of PAs are not evenly distributed. One likely explanation lies in the nature of the tourism and recreation sector in Poland, which – unlike industry – tends to generate seasonal, low-wage jobs concentrated in micro-enterprises, often marked by precarious working conditions (Bednarska & Szutowski, 2013; Ministerstwo Sportu i Turystyki, 2017). Moreover, spatial dependencies appear to amplify these effects, as the negative impact on employment extends to neighbouring municipalities across all types of PAs. Some of the concerns voiced by local communities regarding employment opportunities thus find support in the empirical evidence. Thus, public policies aimed at mitigating negative labour market impacts and ensuring that conservation-driven development benefits are more equally shared are needed, both locally and nationally. Similar tensions between economic and social dimension of development have been documented in other European contexts (Lundmark et al., 2010; Cremer-Schulte & Dissart, 2015), reinforcing the need for further, more granular research on how nature protection affects economic structure, labour relations and income distribution.

The correlation between PAs and the third dimension of local development – public infrastructure for environment protection – proved generally weaker than in the case of economic or social outcomes.[9] A statistically significant and positive relationship was observed only for Natura 2000 areas. This partially confirms the hypothesis that PAs can attract external funding for development of public infrastructure, particularly in cases where conservation overlaps with inhabited and economically utilized land – as it is in the case of Natura 2000 in Poland The effect is not uniform across protection types, and in the case of national parks and nature reserves, the relationship was statistically insignificant. Other factors, such as local natural amenities and the rural character of a municipality, appear to play a more decisive role. Additionally, the ambiguous results for this dimension may reflect the persistence of historical land use patterns, with infrastructure development still largely shaped by geographic constraints and legacy settlement structures (Churski et al., 2020).

Altogether, our results point to the complex relation between the regimes of nature protection and the dimensions of local development, whereby complementarities exist mostly in the dynamics of aggregate incomes and rates of entrepreneurship, while possible trade-offs refer to employment opportunities and risk of poverty. These ambiguous outcomes substantiate the adequacy of our research approach yet also point to directions for further studies. In particular, in the background of our analysis there is a number of macroeconomic and policy factors that mediate the local impacts of nature protection. It refers, for instance, to income policies, labour market structures and regulations which are essential in establishing the actual distribution of costs and benefits of PAs between different economic groups. These underlying factors influence the extent to which conservation measures are perceived as fair or exclusionary. The differing outcomes across protection regimes reinforce the importance of looking more in-depth into the institutional fit analysis, and suggest that more studies are needed into potentials of adaptive governance systems in PAs.

[9] It should be noted, however, that when sewage network expansion is used as the sole measure of infrastructural development, the positive effects become more pronounced and are observable in both SPA and NP areas.

These insights are especially relevant in light of earlier critiques of Natura 2000 implementation, which emphasized that conflicts emerged when local communities perceived the policy as unfair – particularly in terms of recognition and representational justice (Strzelecka et al., 2021). However, participation alone does not guarantee just outcomes if unequal distribution leads to widening inequalities. In fact, the dual effect of PAs – fostering economic growth while hindering social inclusion – may reinforce perceptions of structural inequality and fuel local resentment. To prevent such outcomes, conservation policy must be accompanied by mechanisms addressing distributional injustice. Such "just transition" programmes, originally developed in the context of decarbonization, offer a promising template for designing compensation and support tools for localities affected by expansion of PAs. This is particularly relevant given the ambitious goals outlined in the EU Biodiversity Strategy for 2030, which aims to increase strictly PAs to 10% of the EU's land territory by 2030, compared to 3.4% at present (Cazzola Gatti et al., 2023). Given the identified role of negative spatial spillovers, proposed mitigation policies should take into account not only municipalities directly affected by conservation restrictions, but also neighbouring localities. This should involve coordinated planning efforts that reflect the supra-local nature of labour markets and competitive character of infrastructure investments. At the same time, currently absent positive spillovers from economic development could be enhanced through deliberate efforts to disperse tourist infrastructure, which tends to cluster around sites perceived as 'gateways' to PAs (Wesołowski et al., 2018).

Nature protection is a scientifically grounded response to the accelerating biodiversity crisis, and PAs remain the most established tool for safeguarding ecosystems. As demonstrated in our study, trade-offs between conservation and development do exist, particularly in the social dimension Rather than serving as arguments against conservation, these trade-offs highlight the need for new policies that address distributional injustices. While the expansion of PAs has generated many conflicts, they can also help to advance environmental justice (Bontempi et al., 2023). Their potential depends on embedding them within broader equity-oriented policies, conceived as an integral dimension of the urgently needed just transition.

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