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Synergies in Agricultural Biodiversity Conservation: Decomposing the Interaction Between Nature Parks and Agri-Environment Schemes

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ABSTRACT

Understanding how policy instruments with overlapping goals interact is crucial for leveraging their synergies. This study explores the mechanisms for regional nature parks (a form of protected areas that impose no restrictions on agriculture) to enhance the adoption of biodiversity-conserving agri-environment schemes (AES) in Switzerland. Using data from Switzerland's 2023 farm census of 41,307 farms and a survey of 1009 farms from 2023, and accounting for regional landscape and socio-economic characteristics via matching, we find that the adoption of three types of AES for biodiversity conservation is significantly higher within regional nature parks. To unravel the factors contributing to these differences, we conduct a decomposition analysis to parse out the relative importance of factors influencing AES adoption. We find that higher self-efficacy regarding biodiversity conservation among farmers within parks explains up to 15% of the difference in AES adoption. Additionally, biodiversity goals by cantonal authorities play a key role. These findings suggest that enhancing farmers' perceived control over conservation practices and designing stronger pro-biodiversity policies at regional levels could boost AES adoption, both within and outside park regions. For regions not designated as parks, agencies such as extension services could take up the role of fostering farmers' self-efficacy regarding biodiversity-conserving practices.

JEL Classification: Q15, Q18, Q57, Q58

1 | Introduction

To slow down and reverse biodiversity declines due to agriculture, various policy measures have been implemented globally. Voluntary agri-environment schemes (AES), which provide farmers with financial rewards for pro-environmental practices or positive environmental outcomes, have been a key policy instrument to enhance on-farm biodiversity (Uthes and Matzdorf 2013; Hasler et al. 2022). Another major policy instrument for biodiversity conservation is protected areas (Watson et al. 2014; Maxwell et al. 2020). The effects of both policy instruments have been extensively studied, either separately (e.g., Pe'Er et al. 2019; Naughton-Treves et al. 2005; Watson et al. 2014; Donia et al. 2017) or comparatively (Batáry et al. 2015; dos Santos et al. 2015; Sims and Alix-Garcia 2017; Paulus et al. 2022), indicating the high potential of both instruments to integrate biodiversity conservation in agriculture.

Regional nature parks, as a form of less stringent protected areas that promote sustainable land use, are particularly relevant to agricultural landscapes (EUROPARC 2025), especially since these parks normally do not impose restrictions on farming activities.

Across Europe, regional nature parks fall under the broader concept of Nature Regional Landscape Parks, which covers approximately 8% of Europe (including the European Union, Norway, and Switzerland). For farmers within regional nature parks, both park policies and AES may shape their decision to conserve biodiversity. However, little is understood regarding how regional nature parks may interact with AES to shape farmers' decisions to conserve biodiversity, or how regional nature parks may influence the implementation of biodiversity conservation AES. Knowledge of the potential mechanisms behind the interaction between regional nature parks and AES would enable policymakers to leverage synergies between the two instruments and identify key aspects of the park policies that can be extended to enhance biodiversity on agricultural landscapes not designated as parks.

In this study, we investigate the potential mechanisms for regional nature parks to influence the implementation of biodiversity conservation AES. Our case study focuses on Switzerland, where over 10% of its land area is designated as regional nature parks. We analyze a combination of farm census data, which contain farm-structural information and AES adoption of 41,307 farms, and survey data of 1009 farms with a comprehensive set of behavioral and non-behavioral factors that influence AES adoption, both from the year 2023. Using the census data and propensity score matching, we estimate the differences in the adoption of three types of AES for biodiversity conservation inside and outside parks, matching park- and non-park regions on landscape and socio-economic characteristics. We then repeat these estimations using the survey data to ensure the estimates using the two datasets are consistent and further attribute the estimated differences in AES adoption to various influencing factors in a decomposition analysis.

Unlike highly stringent protected areas such as national parks, regional nature parks aim at both conserving nature and strengthening sustainable economic development. Therefore, these less stringent protected areas can enhance biodiversity while maintaining agricultural production (e.g., Naughton-Treves et al. 2005; Donia et al. 2017; Sims and Alix-Garcia 2017). In particular, regional nature parks can encourage farmers' active engagement in conservation practices by providing knowledge and technical support, and fostering more positive attitudes toward nature and biodiversity (Décamps 2010; Butticaz 2013; de Sainte Marie 2014; Fleury et al. 2015). In this regard, regional nature parks support farmers to fulfill requirements of AES, and thus could facilitate AES implementation. In fact, promoting AES adoption within parks aligns with the conservation objectives of parks, which implies synergies between the two policies (Butticaz 2013). Thus far, however, the literature only provides qualitative and anecdotal evidence on the interaction between regional nature parks and AES, and quantitative evidence is scant (Robalino et al. 2015; Sims and Alix-Garcia 2017; Wang et al. 2025). Furthermore, existing quantitative studies do not address the mechanisms for the interaction, for instance, which aspects of regional nature parks (e.g., generating knowledge, shaping attitude and norms, or providing additional incentives) are most relevant for parks to promote farmers' biodiversity conservation through AES adoption.

Our study contributes to filling this gap by investigating the contributions of various factors to the potential synergies between regional nature parks and AES. We build on previous research that quantifies the interaction between protected areas and AES adoption to further shed light on the mechanisms behind the interaction of the two policy instruments. Our findings highlight specific areas to target for effectively harnessing synergies between regional nature parks and AES to conserve biodiversity. These findings further point to opportunities for adapting relevant aspects of park policies to support agricultural biodiversity conservation in regions not designated as parks. Our study thus adds to the literature on the optimal policy mix for nature and biodiversity conservation in rural regions (e.g., Bouma et al. 2019; Robalino et al. 2015; Ring and Barton 2015; Zárrate Charry et al. 2022).

We find that after accounting for systematic differences between park and non-park regions in terms of landscape and socio-economic characteristics, and farm structural characteristics between farms in these regions, the adoption of all three types of AES is higher inside parks than outside parks. Behavioral factors, in particular higher self-efficacy (i.e., perceived ability to exert control) regarding biodiversity conservation among farmers inside parks, account for up to 17.6% of the higher AES adoption. Therefore, measures to enhance farmers' perceived control of conservation practices could be particularly effective in promoting behavioral changes toward biodiversity conservation. In addition, cantonal effects, which can reflect differences in extension services organized at the canton level, also contribute to the higher AES adoption inside parks. For regions not designated as parks, agencies such as extension services could take up the role of fostering farmers' positive perception that they possess the relevant skills and resources for biodiversity-conserving practices.

2 | Background

2.1 | Regional Nature Parks in Switzerland

Since the establishment of the first Swiss regional nature park in 2008, as of 2023, there are 15 regional nature parks in Switzerland, covering over 10% of its surface area.[1] These parks are operated under the label "Swiss Park of National Importance", granted by the Swiss Federal Office for the Environment, the governmental agency that designs the park policies and oversees the implementation. To create a park, a park authority, organized within the municipalities that constitute a park, must first conduct a feasibility study to ensure the region meets the prerequisite of high natural and scenic value and the commitment of local residents and authorities. Subsequently, a charter is drafted as a core planning tool of the park. Finally, conditional on the Federal Office for the Environment's approval of the charter and a majority vote from park residents in acceptance of the park, the park is established. Parks can then implement various projects planned in the charter, leveraging financial support from the Federal Office for the Environment, respective cantons, municipalities, and self-sought sources.

Unlike strictly protected areas such as national parks that strongly focus on nature conservation and restrict economic activities such as agriculture, regional nature parks ("parks" hereafter) bear the dual objectives of conserving nature and landscape and strengthening sustainable economic development within the parks (NHG, Art. 23 g; Ritzel et al. 2023). As parks are located in rural regions, agriculture is an important sector in parks, and promoting sustainable agriculture is among the common objectives of parks (Trachsel et al. 2020). To promote sustainable agricultural practices, parks organize and coordinate various projects, many of which focus on biodiversity, such as agglomeration projects for biodiversity conservation and promoting landscape features. Along these projects, parks support farmers in various forms, including information events, consultancy services, and financial support for specific activities (e.g., preliminary studies of agglomeration projects). It is important to note that parks only promote sustainable agriculture and do not impose restrictions on agricultural activities, and farmers' participation in park activities is voluntary (Toscan 2007; Frick and Hunziker 2015; Trachsel et al. 2020). Neither do parks displace agricultural policies such as AES or provide additional financial support on top of AES payments.

2.2 | Agri-Environmental Schemes for Biodiversity Conservation in Switzerland

AES have been a major policy instrument in Switzerland to promote ecosystem services in agriculture, with various objectives such as biodiversity conservation, pesticide reduction, and greenhouse gas emission reduction. Our study focus on AES targeted at biodiversity conservation, which was introduced by The Swiss Federal Office for Agriculture in 1993 to incentivize farmers to enroll agricultural land as ecological focus areas. The initial schemes are action-based, which provide direct payments to farmers once they fulfill management requirements such as extensive management of grasslands and buffer strips. Since 1999, participation in biodiversity conservation AES was included as part of a cross-compliance scheme, which requires farmers to enroll at least 7% (3.5% for special crop farms) of their total utilized agricultural area as ecological focus areas to be eligible to receive direct payments. In 2001, the Federal Office for Agriculture introduced two bonus schemes for biodiversity conservation: result-based schemes that offer farmers bonus payments on top of action-based payments for reaching specific biodiversity outcomes on the ecological focus area, that is, occurrence of targeted indicator species (plants, insects, and other animals) (Elmiger et al. 2023), and agglomeration schemes that offer bonus payments on top of action-based payments for spatially connected ecological focus area (e.g., Huber et al. 2021). In the text hereafter, we refer to biodiversity conservation AES simply as "AES", though acknowledging that beyond the context of our study, AES also cover other objectives.

Although the adoption of AES does not directly measure biodiversity outcomes, previous studies have shown that all three types of AES in Switzerland can contribute to higher biodiversity outcomes (Zimmert et al. 2024), especially for result-based and agglomeration AES (e.g., Riedel et al. 2019; Meier et al. 2024; Schaub et al. 2025). We thus contend that AES adoption is a meaningful measure of biodiversity conservation in agriculture.

2.3 | Influencing Factors of AES Adoption and Empirical Hypotheses

To unravel factors associated with farmers' decisions to adopt AES and how parks could influence these factors, we adapt a classification framework in a systematic literature review (Schaub et al. 2023) to our context. The framework places farmers' AES adoption decisions in the economic, social, environmental, and political context, and classifies influencing factors of AES adoption into behavioral factors and opportunity costs. Based on this framework, we investigate behavioral and opportunity-cost-related factors through which parks could influence AES adoption. Behavioral factors determine farmers' personal assumptions of the costs and benefits of adopting AES and their intrinsic motivation for environmentally sustainable practices (Schaub et al. 2023). In this sense, the behavioral factors in our context are equivalent to psychological factors (Dessart et al. 2019). Drawing on the framework, we consider the following groups of factors: (i) information sources regarding biodiversity conservation (i.e., where farmers receive information and advice on conservation practices); (ii) norms regarding biodiversity (how biodiversity conservation is perceived by farmers and their social networks, and how fellow farmers conserve biodiversity); (iii) self-efficacy regarding biodiversity conservation (an important cognitive factor that determines AES adoption), and (iv) attitudes (toward the environment, food production, and policies). Opportunity costs refer to the net benefit a farmer needs to forgo to adapt the current practices to comply with requirements of the AES. We consider the following groups of factors related to the opportunity cost of biodiversity conservation: (i) importance of various sources of income (which depend on market conditions and different types of direct payments), and (ii) farm structural characteristics (which proxy for farm management intensity, implementation efforts of conservation practices, and farm productivity and production costs). In addition to these factors, we also include cantonal factors to account for unobserved differences across cantons that influence AES adoption, which are primarily due to differences in advisory services organized by cantonal agricultural offices (Mack et al. 2020).

Among all the influencing factors of AES adoption discussed above, some generally explain AES adoption but may not contribute to the difference in AES adoption between park and non-park regions. For example, farm size may correlate with AES adoption, but the average farm size within parks does not necessarily differ from that outside of parks. These factors are control variables in our analysis. Other factors may differ systematically between farms inside and outside of parks. Among these, the differences in some factors are due to the non-random location of parks. For instance, parks are more likely to be established in mountainous and rural regions. As a result, a higher fraction of farms inside parks are mountain farms than farms outside of parks. These factors also need to be controlled for in our analysis. Finally, the differences in some factors are likely to be shaped by parks via interactions between farmers and the park.

We hypothesize the last set of factors, namely influencing factors of AES adoption that could be shaped by parks, as the potential mechanisms for parks to influence AES adoption. First, within the group of factors "information sources", information events, consultancy services, and conservation projects organized in parks provide farmers with additional learning opportunities regarding AES and related agricultural practices (Trachsel et al. 2020). These activities provide farmers with additional sources of information and advice on conserving biodiversity. Second, support from parks may enhance farmers' perceived control over relevant conservation practices and increase the (perceived and realized) benefits of adopting AES (Fleury et al. 2015; Tyllianakis and Martin-Ortega 2021). Third, parks may foster more positive attitudes among farmers toward nature conservation (Butticaz 2013), which may in turn facilitate AES adoption. Fourth, the more positive attitude toward nature and biodiversity conservation in parks could further create more positive norms toward biodiversity in the local communities (Fleury et al. 2015). Lastly, the dual objectives of parks to promote sustainable economic development and nature conservation could influence farmers' income structure, which could in turn influence their participation in the AES that provide direct payments. On the one hand, through participating in park projects that facilitate AES adoption, direct payments for biodiversity conservation may become a relatively more important source of income for farmers inside parks. On the other hand, parks could improve the market conditions for farmers and increase their revenue from selling farm products (e.g., via park product label). In this case, farm product sales may become a more important source of income and possibly incur a trade-off between production and biodiversity conservation.

We formulate the following hypotheses which we will test in the empirical analyses. The first hypothesis serves as the basis of the decomposition analysis:

H1. *(AES adoption): Farms inside parks adopt higher fractions of AES than farms outside parks.*

We then test the following hypotheses on the potential mechanisms for parks to enhance AES adoption:

H2. *(information source): Information and advisory sources that are more accessible within parks positively contribute to higher AES adoption inside parks.*

H3. *(self-efficacy): Higher levels of perceived control over biodiversity conservation among farmers in parks positively contribute to higher AES adoption inside parks.*

H4. *(norms): Higher norms regarding biodiversity positively contribute to higher AES adoption inside parks.*

H5. *(pro-environment attitudes): More positive attitudes towards the environment positively contribute to higher AES adoption inside parks.*

H6. *(conservation-related income sources): Higher importance of income related to nature and biodiversity conservation positively contributes to higher AES adoption inside parks.*

3 | Data

We use two datasets to assess the differences in AES adoption inside and outside parks, and factors that contribute to these differences (if any). First, using farm census data, we assess whether there exist systematic differences in AES adoption inside and outside parks across Switzerland. Second, using a combination of survey and census data that contains a rich set of farm and farmers' characteristics influencing AES adoption, we examine the contributions of these factors to the estimated differences.

The Swiss Agricultural Information System maintains the annual farm census data that cover all Swiss farms eligible for direct payments. The dataset contains farm structural characteristics, including farm size, farm type, agricultural zone, and total livestock units, and farms' adoption of direct payment programs, including the biodiversity conservation AES that our study focuses on. These variables characterize the opportunity costs for adopting biodiversity conservation AES which we discuss in Section 2.3, since they jointly provide measures for production cost, management intensity, and implementation effort of AES that are determined by farm structural characteristics. Our analysis of the census data focuses on farms that enrolled in biodiversity conservation AES in 2023, which represent over 99% of all Swiss farms that received direct payments in the same year (see Section 2.2 on the cross-compliance requirement). We consider all three types of AES for biodiversity conservation in our study: (i) action-based, (ii) result-based, and (iii) agglomeration.

To understand factors associated with farmers' decisions to conserve biodiversity, from June to August 2023 we conducted a survey of 2500 farmers in the German- and French-speaking regions of Switzerland. Among these 2500 farmers, 2000 were randomly sampled from all farmers in these two language regions (with a population of 41,307 farmers), and 500 were randomly sampled from all farmers inside parks (with a population of 4513 farmers), both with stratification in agricultural zone and farm type. The survey was available in paper-and-pencil format (delivered by mail) as well as online. Farmers could access the online version via a link provided in the postal mail. In the survey we collected information on various farm and farmer characteristics. We group these characteristics based on the classification framework and the empirical hypotheses H2–H6 discussed in Section 2.3: (i) information sources (farmers' sources of advice and information for biodiversity conservation), among which we consider advisory projects and nature conservation organizations to be more accessible within parks (H2);[2] (ii) farmers' self-efficacy regarding biodiversity conservation (H3); (iii) norms (social and personal norms regarding biodiversity) (H4); (iv) attitudes (attitudes toward production and environment goals of agricultural policies) (H5); and (v) importance of production- and conservation-related sources of income (H6). We received 1009 complete surveys, out of which 228 were inside parks, with an overall response rate of 40%. Although farms inside parks were over-sampled, the final sample is representative of the population of farmers in the Swiss German- and French-speaking regions in terms of farm type, agricultural zone, and farm size. Upon consent from the participating farmers, we merged the survey data with the census data to obtain AES adoption and farm structural information.

Our dependent variables are adoption of action-based, result-based, and agglomeration biodiversity conservation AES, measured as the fraction of utilized agricultural area enrolled into the respective type of AES. Due to the cross-compliance requirement (see Section 2.2), all farms in our sample have positive enrollment in the action-based scheme (with average fraction of 0.22 both in the survey sample and the census data), and the majority of farms also enroll in result-based (0.1 in survey sample and 0.09 in census) and agglomeration (0.19 in survey sample and 0.17 in census) AES.

Table 1 reports the definitions and summary statistics of variables used in the study. In the first column, when applicable, we note the empirical hypothesis with which the variable is associated.

4 | Empirical Strategy

In this section we detail the empirical strategies, which we summarize in Figure 1.

4.1 | Census Data Analysis

We compare AES adoption inside and outside parks by all farms in the census data to test whether there indeed exist systematic differences across all Swiss farms. The purpose of this analysis is to ensure that any difference in AES adoption we find in the survey data would not be due to sampling. The purpose of the analysis with the census data is not to estimate a causal effect of parks on AES adoption, which would require panel data analyses of AES adoption before and after park establishment. Rather, we take the findings from previous research on the interaction between parks and AES adoption as a premise (e.g., Robalino et al. 2015; Sims and Alix-Garcia 2017; Wang et al. 2025), and assess the differences in AES adoption inside and outside parks in a specific year (i.e., in 2023, 5 years after the most recent park establishment in our sample). By doing so, the analyses based on the census data and the survey data are consistent in the time dimension. We acknowledge that any estimated difference in AES adoption inside and outside parks in a specific year is likely to be only partially due to measures implemented by parks. The subsequent decomposition of the contributions of different farm and farmer characteristics will further shed light on which factors are likely to be shaped by park measures and therefore of interest to policymakers.

For each type of biodiversity conservation AES, we calculate the fraction of agricultural land (utilized agricultural area) that is enrolled under action-based, result-based, and agglomeration AES as our dependent variables. A simple comparison of AES adoption inside and outside parks provides limited insights, given that regions where parks are established differ from non-park regions in various aspects such as landscape, land use patterns, and socio-economic status. To ensure that park and non-park regions are comparable in these aspects, we first conduct propensity score matching to construct the comparison groups. Following the literature that assesses the impact of protected areas (e.g., Ferraro and Hanauer 2014; Sims and Alix-Garcia 2017; Robalino et al. 2015), we match park and non-park regions on characteristics relevant to the likelihood that a region becomes a park. Specifically, we match on landscape and ecosystem characteristics (slope, elevation, precipitation, and shares of land cover in forest and woody plants), and socio-economic characteristics (shares of land use for industrial and commercial use, settlement areas, transportation, and population density), measured at the municipality level. To further capture unobserved characteristics related to biodiversity conservation that vary across park and non-park regions, we also include municipality-level average fractions of agricultural land enrolled in each type of AES before park establishment (in 2005) as matching covariates. The unit of observation of the matching covariates accords with the smallest decision unit to become a park, since in the process of establishing a park, each municipality decides whether to join as part of a park (see Section 2.1). In the main analysis, we apply nearest neighbor matching based on generalized Mahalanobis distance (Diamond and Sekhon 2013), and allow for up to 5 control units to be matched to each treated unit. We then compare the AES adoption by farms in the matched park and non-park regions to measure the unconditional gaps in AES adoption (left panel of Figure 1).

4.2 | Survey Data Analysis

To investigate the mechanisms for which parks could impact farmers' biodiversity conservation, using the survey data, we estimate both unconditional and conditional gaps of AES adoption inside and outside parks, and then decompose the difference of these two gaps over groups of farm and farmer characteristics (right panel of Figure 1). As with the analysis of the census data, for the survey data, we also match on landscape and socio-economic characteristics to construct the comparison groups since these characteristics contribute to the likelihood that a region becomes a park. We again allow for up to 5 control units to be matched to each treated unit. In addition, since our survey sample was stratified by farm type and agricultural zone, but not by municipality, after matching on municipality characteristics, imbalances in farm structural characteristics between farms inside and outside of parks may still exist. In such cases, farm structural characteristics correlate with the probability of being inside parks in the survey sample and need to be further balanced. This is because some farm characteristics are more prevalent among farms inside parks, for instance, farms in mountain zones and cattle farms. Therefore, we further match farms inside and outside parks on farm structural characteristics, including farm type, agricultural zone, livestock density, farm size, and whether the farm produces organically.

The decomposition method, introduced in Gelbach (2016), essentially decomposes the omitted variable bias in ordinary least squares (OLS) regression and is independent of the sequence that the covariates are added. Therefore, assumptions of OLS regressions also apply to the method. Implementing the method takes three steps. First, using the matched sample, we estimate two models on the relationship between park status and AES adoption to obtain the unconditional and conditional gaps of AES adoption inside and outside parks. A simple linear model (termed the "base" model in Gelbach (2016)), where an indicator of park status is the only explanatory variable of AES adoption, yields an estimate of the unconditional gap. A full model, where relevant farm and farmer characteristics are included as covariates, yields an estimate of the conditional gap:

TABLE 1 | Variable description and summary statistics.

Variable name (related empirical hypothesis)	Description/ survey item	Unit (measurement scale)	Mean/ frequency
Information sources	"Which sources of information and advice do you use for implementing and maintaining ecological focus areas?"	(Binary) 1 = Yes; 0 = No	Share of Yes in %
Colleagues			65
Cantonal extension service			54
Advisory project (H2)			27
Nature conservation organizations (H2)			9
Agricultural magazines			58
Self-efficacy (H3)		(Likert scale)	
Self-efficacy—personal skills	"I possess the necessary skills and knowledge to enhance biodiversity on my farm."	From *1 = Does not apply at all* to *7 = Fully applies*	5.3
Self-efficacy—damage prevention	"I am confident that I can prevent damage to biodiversity caused by agricultural production."		5.4
Self-efficacy—overcoming difficulties	"If difficulties arise when implementing measures to enhance biodiversity, I usually find a solution."		5.3
Norms (H4)		(Likert scale)	
Personal norm	"I think it is important to take measures to promote biodiversity on my farm."	From *1 = Does not apply at all* to *7 = Fully applies*	4.9
Injunctive norm—family	"My family members expect me to take measures to promote biodiversity on my farm."		3.5
Injunctive norm—acquaintances	"Most of my acquaintances expect me to take measures to promote biodiversity on my farm."		3.4
Descriptive norm—other farmers	"Most of the farmers I personally know take measures to promote biodiversity on their farms."		4.4

(Continues)

TABLE 1 | (Continued)

Variable name (related empirical hypothesis)	Description/ survey item	Unit (measurement scale)	Mean/ frequency
Attitudes		(Likert scale)	
Agricultural policy-income	"Agricultural policy measures to ensure farm income are…"	From *1 = Too little* to *7 = Too much*	2.8
Agricultural policy-self-sufficiency	"Agricultural policy measures to ensure national self-sufficiency are…"		2.2
Agricultural policy-environment (H5)	"Agricultural policy measures to protect the environment and biodiversity are…"		4.7
Agricultural policy-biodiversity (H5)	"In the distribution of agricultural budget, biodiversity is…"		4.4
Income sources	"Please indicate how important the different sources of income are for your farm's total income."	(Likert scale)	
From *1 = Not important at all* to *7 = Very important*			
Importance of market income	Income from farm sales		5.9
Importance of biodiversity payments (H6)	Payments for EFA		5.1
Importance of cultural landscape payments (H6)	Payments for both EFA and productive areas (non-EFA)		5.0
Importance of production system payments (H6)	Payments for less intensive productive areas and animal welfare		5.5
Importance of food security payments	Payments for mainly productive areas		5.7
Farm strucutral characteristics (survey sample)			
Farm type		(Nominal scale)	
1 = Arable farming		Share in %	5.9
2 = Special cultures			7.0
3 = Dairy cows			26.8
4 = Suckler cows			12.6
5 = Cattle mixed			8.3
6 = Horses/sheep/goats			5.6
7 = Processing			1.5
8 = Combined dairy cows/arable farming			4.2
9 = Combined suckler cows			4.2

(Continues)

TABLE 1 | (Continued)

Variable name (related empirical hypothesis)	Description/ survey item	Unit (measurement scale)	Mean/ frequency
10 = Combined processing			9.0
11 = Combined others			15.0
Agricultural zone		(Nominal scale)	
1 = Valley		Share in %	41.7
2 = Hill			14.2
3 = Mountain I			13.3
4 = Mountain II			18.5
5 = Mountain III			7.6
6 = Mountain IV			4.7
Production system	1 = Organic, 0 = non-organic	Share in % organic (binary)	22
Utilized agricultural area		Hectare (continuous)	23.4
Livestock units		Reference unit for livestock (continuous)	26.4
Sociodemographic characteristics			
Farmer age		Years (continuous)	48.6
Education level		(Nominal scale)	
1 = Practical experience		Share in %	6.0
2 = Federal vocational certificate (EBA)			0.3
3 = Federal certificate of competence (EFZ)			4.5
4 = Professional examination			44.9
5 = Master's examination			11.9
6 = Higher college			20.8
7 = Bachelor's degree or higher			4.4
8 = Other education			4.2

Note: Numbers of observation: 1009 for survey sample (out of which 228 are inside parks), and 41,307 for farm census (out of which 4513 are inside parks).

$$Y_i = \beta^{base} park_i + \epsilon_i^{base}$$

$$Y_i = \beta^{full} park_i + X_i \gamma + \epsilon_i^{full}$$

where Y_i is AES adoption of farm i, $park_i$ is an indicator that equals 1 if farm i is located inside a park, and 0 otherwise. We specify the full model based on discussions in Section 2.3: in the vector X_i we include behavioral factors, farm structural characteristics, farmer socio-demographic characteristics, and cantonal dummies that account for unobserved differences across cantons that influence AES adoption (Mack et al. 2020), for example, extension services organized by cantonal agricultural services. In the full regression model, farm structural characteristics explain the general variation in AES adoption across for example, farm types and agricultural zones. Although between farms inside and outside parks, we balance farm structural characteristics via matching, within either farms inside or outside parks, AES adoption still vary across farm structural characteristics. Therefore, it is necessary to further include these covariates in the full model.

Second, assuming the full model is well-specified, we calculate the difference in the coefficient estimates of *park* between the full model and the base model, $\hat{\delta} = \hat{\beta}^{base} - \hat{\beta}^{full}$, which measures the extent to which the unconditional "gap" in AES adoption estimated in the base model is explained by the covariates in the full model.

Third, we decompose $\hat{\delta}$ first by running an auxiliary regression of each group of covariates, namely information sources, norms, self-efficacy regarding biodiversity conservation, and importance of different sources of income, on the park indicator. These auxiliary regressions yield group-specific components of the omitted variable bias in the base model. Specifically, for each group g of covariates in the full model, we create a heterogeneity variable $\hat{H}_i^g = \Sigma_{k \in g} X'_{k_i} \hat{\gamma}_{k_i}$, where k is the kth covariate in group g. $\hat{H}_i^g$ measures the component of farm i's AES adoption that is

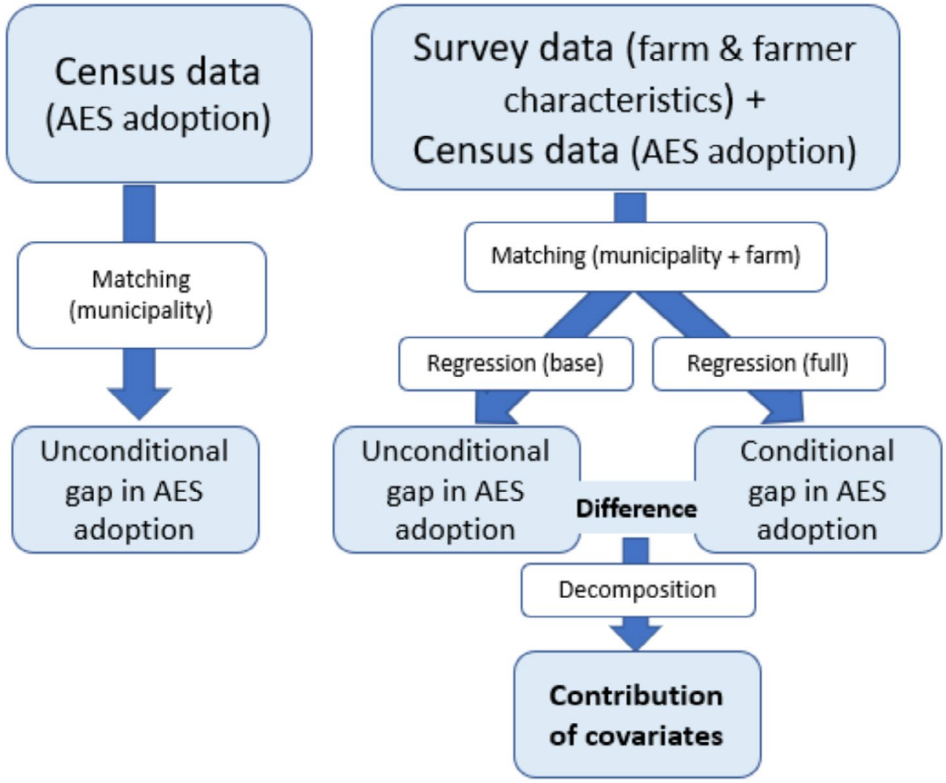

FIGURE 1 | Summary of empirical strategy and corresponding data.

explained by i's values of covariates in group g. Then, regressing $\widehat{H}_i^g$ on the park indicator, we obtain the coefficient estimate $\widehat{\delta}^g$. We can then attribute $\widehat{\delta}$ to variations in each group of covariates by calculating the fraction of $\widehat{\delta}^g$ relative to $\widehat{\delta}$. By construction, whether variation in group g of covariates increases or reduce the gap (determined by the signs of $\widehat{\delta}^g$ and $\widehat{\delta}$) depends on two components: (i) the correlation between these covariates and AES adoption (holding other covariates fixed), and (ii) the differences in mean values of the covariates between farms in park regions and non-parks regions. In the results section we will discuss for each group g of covariates, how these two components jointly determine $\widehat{\delta}^g$.

4.3 | Robustness Checks

We conduct robustness checks to verify the reliability of the results from the main analyses, in particular, that these results do not depend on the comparison groups constructed by the matching procedure. To ensure the estimated differences in AES adoption do not hinge on the matching models, we apply alternative matching specifications to construct the comparison groups. As an alternative matching algorithm, we apply optimal pair matching based on Mahalanobis distance (Ho et al. 2007).

5 | Results and Discussion

In this section, we report the estimated differences in AES adoption inside and outside of parks, both based on the census data and survey data. As we show below, using both datasets, we find that farms inside parks adopt more AES per hectare of utilized agricultural area. We then report the decomposition results of these differences and discuss the implications.

5.1 | Differences in AES Adoption Inside and Outside Parks

Table 2 reports the differences in AES adoption between park and non-park regions in 2023, based on the census data. A simple (unmatched) comparison among all Swiss farms shows that on average, farms inside parks enrolled 2.4, 2.4, and 3.9 percentage points more land into action-based, result-based, and agglomeration AES, respectively. After restricting the comparison group to regions with similar landscape and socio-economic characteristics via matching, we continue to find that farms inside parks outperform farms outside of parks in terms of AES adoption, though the magnitudes are reduced (1.6, 1.1, and 3.1 percentage points, respectively). The larger gap in the adoption of agglomeration AES is likely due to the coordination costs associated with agglomeration projects. Since parks typically organize agglomeration projects to facilitate farmers' participation (Butticaz 2013), they may reduce the coordination costs, and thus are particularly effective in increasing adoption of agglomeration schemes. Table A1 in the appendix shows that all covariates are balanced after matching.

These results indicate that the matching covariates partially account for the gaps in AES adoption inside and outside parks, as evidenced by the reduced magnitudes after matching. However, the remaining statistically significant gaps indicate that

TABLE 2 | Difference in AES adoption inside and outside parks based on census data.

	Action-based		Result-based		Agglomeration	
	Unmatched	**Matched**	**Unmatched**	**Matched**	**Unmatched**	**Matched**
Park	0.024*** (0.003)	0.016*** (0.004)	0.024*** (0.002)	0.011*** (0.003)	0.039*** (0.003)	0.031*** (0.004)
N	41,307	7663	41,307	7663	41,307	7663

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses.

TABLE 3 | Coefficient estimates of park on AES adoption based on matched survey data ($N = 582$).

	Action-based		Result-based		Agglomeration	
Model	**Base**	**Full**	**Base**	**Full**	**Base**	**Full**
Park	0.025* (0.014)	−0.003 (0.015)	0.021** (0.011)	−0.003 (0.012)	0.044*** (0.015)	0.006 (0.015)
Adj. R^2	0.005	0.39	0.004	0.35	0.014	0.35

Note: *, **, and *** denote statistical significance at the 10%, 5%, and the 1% levels, respectively. Standard errors are in parentheses.

landscape and socio-economic characteristics do not to fully explain the differences. Further analysis of the survey data to examine whether farm and farmer characteristics account for the gaps in AES adoption is therefore warranted.

Table 3 reports the coefficient estimates of the park indicator in the base and full models using the survey data. We report the coefficient estimates of the other covariates of the full model in Table A2 in the appendix. The estimated differences based on the survey data are larger compared to those based on the census data, likely because farms inside parks were over-represented in the survey data (Section 3). Nonetheless, it is important that the estimated differences are qualitatively consistent with estimates based on the census data (i.e., positive and statistically significant). As we include farm and farmer characteristics in the full model, the park indicator is close to zero and no longer statistically significant. The insignificant park indicator in the full model shows that variations in the additional farm and farmer characteristics account for the differences in AES adoption between farms inside and outside parks. Next, we decompose the contribution of these characteristics to the estimated differences in AES adoption between farms inside and outside parks.

5.2 | Decomposing Differences in AES Adoption Inside and Outside Parks

Table 4 reports the results of the decomposition analysis. For each type of AES, the first column reports the coefficient estimates of regressing the heterogeneity variable on the park indicator, $\widehat{\delta}^g$, and the second column reports the percentage of $\widehat{\delta}^g$ relative to the estimated total gap $\widehat{\delta}$. Since $\widehat{\delta}$ are positive for all types of AES, a positive and statistically significant $\widehat{\delta}^g$ indicates that the respective group of covariates explains the gap in AES adoption. That is, if the mean values of covariates group g were the same between park- and non-park regions and all other covariates are held fixed, the gap in AES adoption would be reduced. By contrast, a negative and statistically significant $\widehat{\delta}^g$ indicates that if the mean values of covariates group g were the same between park- and non-park regions, the gap would be larger. An insignificant $\widehat{\delta}^g$ indicates that variation in covariates group g does not affect the gap in AES adoption.

Recall that $\widehat{\delta}^g$ is the coefficient estimates of regressing the heterogeneity variable $\widehat{H}^g$ on the park indicator, where $\widehat{H}^g = \Sigma_{k \in g} X'_k \widehat{\gamma}_k$, and $\widehat{\gamma}_k$ is the coefficient estimate of covariate k in group g in the full regression model. By construction, $\widehat{\delta}^g$ depends on two components: (i) the conditional correlation between AES adoption and group g of covariates (i.e., the coefficient estimates of covariates group g in the full model), and (ii) the mean difference in the covariates between farms in park- and non-parks regions. Intuitively, covariates that significantly contribute to the gap in AES adoption should (i) correlate with AES adoption, and (ii) correlate with park status (i.e., differ between farms inside and outside parks). If either of the two correlations is statistically insignificant, the correlations are orthogonal to each other, leading to an insignificant joint effect of $\widehat{\delta}^g$. For details of each covariate k in group g that constitute $\widehat{\delta}^g$, we report the coefficient estimates of individual covariates in the full model in Table A2 (i.e., component (i) at the individual covariate level), and the t-statistics comparing continuous covariates of farms inside and outside parks in Table A3 (i.e., component (ii) at the individual covariate level).

The coefficient estimates of the group of covariates farm structure, $\widehat{\delta}^{farm\ structure}$ are statistically insignificant across all types of AES, which is expected given that we balance these covariates via matching, such that the mean differences of these covariates inside and outside parks are effectively zero. The magnitudes of the (insignificant) estimates are up to 24.7% of the total gap in AES adoption inside and outside parks. Taking a closer look into the regression results of the full model (Table A2), several farm structural characteristics explain the general variation in AES adoption, including farm size, agricultural zone, and farm type. The high conditional correlation between AES adoption and farm structural characteristics likely results in the relatively large magnitude of $\widehat{\delta}^{farm\ structure}$. This correlation, however, is orthogonal to the correlation between farm structural characteristics and parks status due to matching, and therefore the combined effect of $\widehat{\delta}^{farm\ structure}$ is statistically insignificant.

TABLE 4 | Decomposition of gaps in AES adoption between farms inside and outside parks.

	Action-based		Result-based		Agglomeration	
	Estimate	**% Gap**	**Estimate**	**% Gap**	**Estimate**	**% Gap**
Farm structure	0.0069	24.73%	0.0056	22.88%	0.0077	20.46%
	(0.006)		(0.003)		(0.006)	
Farmer socio-demographic	−0.0001	−0.36%	0.0002	0.82%	−0.0001	−0.27%
	(0.0005)		(0.0003)		(0.001)	
Norms regarding biodiversity	0.0006	2.15%	−0.0001	−0.41%	0.0008	2.13%
	(0.003)		(0.001)		(0.003)	
Self-efficacy	0.0049***	17.56%	0.0043**	17.57%	0.0063***	16.74%
	(0.002)		(0.002)		(0.002)	
Information sources (*conventional*)	−0.0014	−5.02%	−0.0003	−1.23%	−0.0019	−5.05%
	(0.001)		(0.0004)		(0.001)	
Information sources (*park-related*)	0.0003	1.08%	0.0002	0.82%	0.0002	0.53%
	(0.0007)		(0.0003)		(0.0003)	
Attitudes (*pro-production*)	−0.0007	−2.51%	−0.0002	−0.82%	0.0003	0.08%
	(0.001)		(0.001)		(0.001)	
Attitudes (*pro-environment*)	0.0008	2.87%	−0.0002	−0.82%	0.0005	1.33%
	(0.001)		(0.001)		(0.001)	
Income sources (*production*)	−0.0026	−9.32%	−0.0013	−5.31%	−0.0023	−6.11%
	(0.002)		(0.001)		(0.002)	
Income sources (*conservation*)	0.0063***	22.58%	0.0063***	25.74%	0.008***	21.26%
	(0.002)		(0.002)		(0.003)	
Canton	0.0129***	46.23%	0.0102*	41.67%	0.0184***	48.89%
	(0.004)		(0.005)		(0.003)	

Note: Decomposition of gaps in action-based, result-based, and agglomeration EFA between farms inside and outside farms. Columns "Estimate" report coefficient estimates of the park indicator from auxiliary regressions of each heterogeneity variable constructed from each group of covariates. Columns "% Gap" report the percentage of the coefficient estimate relative to the corresponding EFA gap. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses.

For farmer socio-demographic characteristics, the estimate $\hat{\delta}^{socio-demo}$ is statistically insignificant with low magnitude. Regression results of the full model show that neither farmer education nor age have a significant conditional correlation with AES adoption (Table A2). Moreover, farmers inside and outside parks do not significantly differ in these regards (Table A3). As a result, this group of covariates does not significantly contribute to the gap in AES adoption.

For norms regarding biodiversity, we again find a statistically insignificant estimate of $\hat{\delta}^{norms}$ with low magnitude. Regression results show that within the group of norms, personal norms and descriptive norms have opposite conditional correlations with AES adoption. Since all norm variables are measured as perceived norms, a possible explanation for the negative conditional correlation between descriptive norms and AES adoption is that, farmers who engage less in biodiversity conservation may tend to overestimate the engagement of other farmers, hence the higher perceived descriptive norm. Nonetheless, the mean differences in all norm variables inside and outside parks are statistically insignificant (i.e., orthogonal to the conditional correlations between these covariates and AES adoption), leading to an insignificant estimate of $\hat{\delta}^{norms}$.

Self-efficacy regarding biodiversity conservation explains up to 17.6% of the gap between park and non-park farms and is statistically significant. That is, conditional on all other covariates, the gap would be up to 17.6% smaller if self-efficacy of farmers in non-park regions were as high as self-efficacy of farmers in parks. Regression results show that "self-efficacy-personal skills" has a positive and significant correlation with AES adoption of all types. A mean comparison shows that farmers inside parks reported higher average values in the same variable. Therefore, the contribution of the group self-efficacy is primarily due to the higher perceived control in the skills for conserving biodiversity among farmers inside parks.

For information sources, the contributions of both subgroups, conventional and park-related, are statistically insignificant and of low magnitudes. Comparing the mean values, farms inside parks consult to a lesser extent trade journals for advice on conserving biodiversity. However, regression results show that none of the information sources has a significant conditional correlation with AES adoption, leading to an insignificant contribution of this group of covariates.

For attitudes, we also find insignificant contributions of both subgroups, pro-production and pro-environment. Regression results show that none of the attitude variables have a significant conditional correlation with AES adoption. Furthermore, farmers inside and outside parks do not differ significantly in any of the attitude domains.

For income sources, we find opposite patterns of the two subgroups, production and conservation. Across all types of AES, production-related income sources negatively contribute to the gaps in AES adoption, albeit statistically insignificant. By contrast, conservation-related income sources positively and statistically significantly contribute to the gaps. Regression results indicate a general trade-off between production and conservation, with income from farm sales and food security payments negatively correlating with AES adoption, and biodiversity payments positively correlating with the adoption of result-based and agglomeration AES. Mean comparisons show that there is no significant difference in the importance of production-related income sources between farms inside and outside parks, whereas conservation-related income sources (biodiversity, production systems, and cultural landscapes) are more important to farms inside parks.[3] The latter, combined with the significant conditional correlation between biodiversity payments and AES adoption, leads to a positive and significant contribution of conservation-related income sources.

Canton dummies also account for a large fraction of the gap in AES adoption (up to 48.9%). Regression results of the full model show that AES adoption vary significantly across cantons, indicating that canton-level factors such as extension services organized by cantonal agricultural offices could influence AES adoption (Mack et al. 2020). Since parks are not located in all cantons, canton membership varies systematically between park- and (some) non-park farms by default. The fact that the combined effect, namely $\hat{\delta}^{canton}$ is also statistically significant, indicates that the conditional correlation between AES adoption and cantons is not orthogonal to the correlation between park status and cantons. In other words, in cantons where parks are established, AES adoption tend to be generally higher than in cantons where no park is established. A comparison of AES adoption between cantons with and without parks indeed shows that farms in cantons where parks are established (either inside or outside of parks) on average adopt more AES than farms in cantons where no park is established. These results indicate that while AES are designed at the federal level, support at lower (e.g., cantonal) levels for example, via extension services likely influence the adoption of AES.[4]

5.3 | Robustness Checks

Table A4 report results of robustness checks with optimal pair matching. Results show that the estimated differences in AES adoption between farms inside and outside parks remain stable to alternative matching algorithms. Therefore, the estimated differences in AES adoption inside and outside parks are unlikely to hinge on the matching model specifications.

6 | Discussion and Policy Implications

Taken together, we find higher AES adoption among farms inside parks compared to farms outside parks, after controlling for landscape, socio-economic, and farm structural differences across park- and non-park regions. These differences in AES adoption are largely attributable to the differences inside and outside parks in farmers' self-efficacy regarding biodiversity conservation, the importance of conservation-related income sources, and cantonal support of AES adoption for example, via extension services.

Our finding that higher self-efficacy of farmers within parks explains the higher AES adoption is consistent with previous literature on the impact of cognitive factors on farmers' decision to adopt sustainable practices, such as agroforestry (McGinty et al. 2008), pesticide reduction (Bakker et al. 2021), and biodiversity conservation (van Dijk et al. 2016; Ritzel et al. 2025). Cognitive factors such as self-efficacy are very specific to the decision-making process in question, and therefore can be relatively easily altered by policy interventions (Dessart et al. 2019). In our context, farmers' perceptions of biodiversity-conserving practices, particularly their perceived control over these practices relative to the possible difficulties, are likely to be positively shaped by park activities, such as technical assistance and consultancy services that support biodiversity-conserving practices. For instance, it is common for parks to organize projects that assist farmers in implementing biodiversity conservation measures such as landscape features (Trachsel et al. 2020). These hands-on learning opportunities, as well as easy access to relevant knowledge and skills via advisors and peers, may strengthen farmers' perception that they possess the necessary skills of conservation practices. This mechanism of increasing AES adoption via higher self-efficacy can potentially be transferred to non-park regions. Through interaction with farmers, agricultural advisors could identify the reasons for a lack of perceived control over biodiversity conservation among farmers, and design strategies to address the barriers. For instance, instead of park authorities, other agencies in non-park regions, such as extension services, can tailor their support to enhance farmers' self-efficacy in conserving biodiversity. For instance, agricultural advisors can provide hands-on, practical training that builds farmers' confidence in specific tasks in biodiversity conservation, such as installing landscape features on the farm. Extension services could also foster community-based peer learning to allow farmers to learn from and become motivated by colleagues who successfully implemented conservation measures (McGinty et al. 2008).

Our finding that the higher AES adoption in parks is associated with cantonal effects suggests that while AES are designed at the federal level, support to farmers at lower administrative levels where AES are implemented may facilitate the uptake (Mack et al. 2020). For regions not designated as parks, stronger support from extension services oriented at biodiversity conservation may promote AES adoption by influencing either farmers' perception (i.e., behavioral aspects) or opportunity costs regarding biodiversity-conserving practices.

As of the higher importance of conservation-related payments as income sources, it is possible that park activities regarding sustainable agricultural practices and maintaining cultural landscapes have raised farmers' awareness of these payment schemes as sources of additional income, as well as their self-efficacy to fulfill requirements of the schemes. The higher (perceived and actual) benefits of these schemes in terms of income generation could have contributed to farmers' decisions to adopt the schemes. Alternatively, since the importance of income sources is measured several years after parks were established, the higher perceived importance of conservation-related income sources (measured in 2023) could also be a result of higher AES adoption inside parks.

Our findings on the interaction between parks and national agri-environmental schemes bear policy implications beyond the context of Switzerland. Across Europe, the alignment between agricultural and nature conservation policies remains ecologically and institutionally fragmented, resulting in limited effectiveness in conserving biodiversity (Hodge et al. 2015). Recent policy developments, such as the Nature Restoration Law which sets binding targets for increasing biodiversity in agricultural ecosystems (European Commission 2025), highlight the increasing coherence of objectives in environmental and agricultural policies, and call for strategies to operationalize these objectives. As part of the over 900 nature regional landscape parks across Europe (EUROPARC 2025), Swiss regional nature parks represent regional governance structures designed to integrate nature and biodiversity conservation into sustainable agriculture. The bottom-up and participatory governance structures of parks can foster communication and collaboration between farmers and local authorities, thereby enabling local agencies to tailor support of AES adoption to local contexts and specific needs of farmers, and ultimately enhance conservation outcomes via the implementation of AES. Leveraging and strengthening the synergy between regional governance and national agri-environmental policies can therefore foster more integrated approaches to land management and biodiversity conservation across Europe.

Our study has several limitations. Our decomposition analysis is based on a cross-sectional survey that measures farm and farmer characteristics in 1 year. Measurement of these characteristics over time and both before and after park establishment would provide deeper insights into how the parks could shape certain farmer characteristics, especially behavioral aspects, such as the importance of different income sources discussed above. Nonetheless, for behavioral factors such as self-efficacy regarding biodiversity, we contend that the higher self-efficacy of farmers inside parks is plausibly attributable to the establishment of parks, since it is highly unlikely that before park establishment, farmers inside and outside parks systematically differed in these aspects. Furthermore, our study focuses on how parks change farmers' behavior (i.e., in terms of adopting AES) and does not address the environmental outcomes (e.g., species richness) due to park establishment. The implication for biodiversity outcomes therefore hinges on previous literature on the link between AES adoption and biodiversity outcomes in the Swiss context (e.g., Riedel et al. 2019; Meier et al. 2024; Zimmert et al. 2024; Schaub et al. 2025).

7 | Conclusion

To leverage synergies between different policy instruments aimed at integrating biodiversity into agriculture, knowledge of the mechanisms behind the interactions of these policies is crucial. In this study, we investigate why farms inside regional nature parks adopt more AES for biodiversity conservation by parsing out the contributions of various factors that influence AES adoption. We underscore that to understand the mechanisms for parks to influence AES adoption, it is important to account for factors that differ systematically inside and outside parks before parks were established or are not influenced by parks, such as regional landscape and socio-economic characteristics and farm-level structural characteristics. Our findings indicate that after controlling for these factors, the higher AES adoption within parks is primarily explained by cantonal effects, conservation-related income sources, and farmers' self-efficacy regarding biodiversity-conserving practices. Providing support regarding conservation practices at the regional level and implementing measures that foster farmers' positive perception of their control over biodiversity-conserving practices therefore bear potential to increase AES adoption within parks as well as in regions not designated as parks.

For future research that investigates behavioral aspects as potential mechanisms for policies to impact farmer behavior, our study suggests that baseline assessments of farmers' behavioral characteristics (i.e., before the policy is implemented) can facilitate identifying the causal mechanism for the policy effects, especially those that could be influenced by the outcome of interest. Furthermore, provided that indicators of biodiversity outcomes can be made available at large scales, future research that uses such indicators as outcomes would add insights into how parks enhance actual biodiversity outcomes in agricultural landscapes.

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Data Availability Statement

The data that support the findings of this study are available from Swiss Federal Office for Agriculture. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the author(s) with the permission of Swiss Federal Office for Agriculture.

Endnotes

[1] As of 2025, there are 16 regional nature parks and one park candidate. We study the 15 parks that have been established at the time our survey data were collected in 2023.

[2] Advisory projects and nature conservation organizations can also be available to farmers outside parks. Here we do not claim that these information sources are exclusive to farmers inside parks, but rather that

they are relatively more accessible within parks due to park activities that provide farmers with additional learning opportunities regarding AES and related agricultural practices (Trachsel et al. 2020).

[3] The direct payment schemes for production systems and cultural landscapes aim to promote and preserve diverse cultural landscapes on agricultural lands (DZV 2024), and such landscapes are typical within parks.

[4] To further parse out the cantonal policy effects, we would need to restrict the sample to only cantons with parks, and compare AES adoption of park- and non-park farms in these cantons. However, this is not feasible due to the limited numbers of observations in cantons where parks are established, especially in the non-park regions of these cantons. Furthermore, since parks are located in regions with certain landscape and socio-economic characteristics, non-park regions in the same cantons likely differ in these aspects from park regions. Therefore, it would not be feasible to construct a comparison group via matching on these characteristics.

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Appendix A

TABLE A1 | Covariate balance before and after municipality-level matching.

	All parks	All non-park	Matched non-park
Elevation (m)	1018	711	982.0
Slope (degree)	13.9	9.7	13.7
Precipitation (mm/year)	1108	1082	1131.6
Forest (%)	37.1	28.6	36.2
Woods (%)	2.9	1.8	2.8
Industrial and commercial (%)	0.3	1.3*	0.3
Settlement (%)	3.2	7.9*	3.2
Transportation (%)	2.2	4.4*	2.1
Population density (head/ha)	1.2	4.3*	1.1

Note: Mean values of covariates in commune-level matching for treated and (matched) control groups. * indicates that the covariate is not balanced between the treated and control groups before matching, either by standardized mean difference greater than 1 or variance ratio greater than 2. All covariates are balanced after matching. Units are indicated in parentheses (m: meter; mm: millimeter; %: percent; ha: hectare). Data of elevation and slope are from the Shuttle Radar Topography Mission, precipitation is from MeteoSuisse, land cover and land use are from Arealstatistik 2004/2009 (a national survey).

TABLE A2 | Coefficient estimates of full model of AES adoption.

	Action-based	Result-based	Agglomeration
	(1)	(2)	(3)
Park	−0.003	−0.004	0.007
	(0.015)	(0.012)	(0.015)
Farm Size	0.002**	0.001*	0.002**
	(0.001)	(0.001)	(0.001)
Agricultural zone: Hill	0.087***	0.058***	0.100***
	(0.024)	(0.019)	(0.024)
Agricultural zone: Mountain 1	0.061**	0.047**	0.081***
	(0.026)	(0.021)	(0.027)
Agricultural zone: Mountain 2	0.099***	0.084***	0.116***
	(0.027)	(0.022)	(0.028)
Agricultural zone: Mountain 3	0.131***	0.149***	0.168***
	(0.032)	(0.026)	(0.033)
Agricultural zone: Mountain 4	0.256***	0.223***	0.258***
	(0.038)	(0.031)	(0.039)
Farm type: Special cultures	0.177***	0.053	0.185***
	(0.051)	(0.042)	(0.053)
Farm type: Dairy cows	0.046	0.040	0.042
	(0.045)	(0.037)	(0.047)
Farm type: Suckler cows	0.082*	0.065*	0.075
	(0.046)	(0.038)	(0.048)
Farm type: Cattle mixed	0.064	0.046	0.052
	(0.047)	(0.039)	(0.049)
Farm type: Horses/sheep/goats	0.133***	0.067	0.121**
	(0.051)	(0.042)	(0.053)
Farm type: Processing	0.072	0.077	0.051
	(0.073)	(0.060)	(0.076)
Farm type: Combined dairy cows/arable	0.020	0.031	0.049
	(0.057)	(0.047)	(0.059)
Farm type: Combined suckler cows	0.119**	0.050	0.109**
	(0.050)	(0.041)	(0.051)
Farm type: Combined processing	0.107**	0.081**	0.115**
	(0.048)	(0.039)	(0.049)
Farm type: Combined other	0.101**	0.071**	0.101**
	(0.042)	(0.034)	(0.043)
Organic	0.006	0.010	0.006
	(0.016)	(0.013)	(0.017)
Livestock units	−0.002***	−0.001***	−0.002***
	(0.0005)	(0.0004)	(0.0005)

(Continues)

	Action-based	Result-based	Agglomeration
	(1)	(2)	(3)
Farmer age	−0.0001	−0.001	−0.001
	(0.001)	(0.001)	(0.001)
Farmer education	0.003	−0.001	0.006
	(0.004)	(0.003)	(0.004)
Information: Advisory project	0.006	0.003	0.003
	(0.014)	(0.012)	(0.015)
Information: Nature conservation organizations	0.007	0.001	−0.010
	(0.022)	(0.018)	(0.022)
Information: Colleagues	0.018	0.008	0.020
	(0.013)	(0.011)	(0.013)
Information: Cantonal extension service	−0.015	−0.002	−0.003
	(0.012)	(0.010)	(0.013)
Information: Agricultural magazines	0.005	0.002	0.013
	(0.013)	(0.010)	(0.013)
Personal norm	0.018***	0.007	0.021***
	(0.005)	(0.004)	(0.006)
Injunctive norm—family	0.001	0.001	0.001
	(0.005)	(0.004)	(0.005)
Injunctive norm—acquaintances	−0.003	−0.001	−0.004
	(0.005)	(0.004)	(0.005)
Descriptive norm—other farmers	−0.018***	−0.009***	−0.020***
	(0.004)	(0.003)	(0.004)
Self-efficacy—personal skills	0.019***	0.014***	0.025***
	(0.006)	(0.005)	(0.006)
Self-efficacy—damage prevention	−0.003	−0.003	−0.006
	(0.005)	(0.004)	(0.006)
Self-efficacy—overcoming difficulties	−0.006	0.002	−0.006
	(0.006)	(0.005)	(0.006)
Attitudes: Agricultural policy-biodiversity	0.004	−0.001	0.003
	(0.005)	(0.004)	(0.006)
Attitudes: Agricultural policy-environment	−0.002	−0.005	−0.004
	(0.004)	(0.004)	(0.005)
Attitudes: Agricultural policy-income	0.004	0.004	0.006
	(0.005)	(0.004)	(0.005)
Attitudes: Agricultural policy-self-sufficiency	0.009	0.006	0.006
	(0.005)	(0.004)	(0.006)
Income: Farm sales	−0.008*	−0.003	−0.008*
	(0.004)	(0.003)	(0.004)

(Continues)

TABLE A2 | (Continued)

	Action-based	Result-based	Agglomeration
	(1)	(2)	(3)
Income: Off-farm	0.003	0.001	0.002
	(0.003)	(0.002)	(0.003)
Income: Food security payments	−0.015***	−0.008**	−0.013***
	(0.005)	(0.004)	(0.005)
Income: Biodiversity payments	0.007	0.013***	0.011**
	(0.005)	(0.004)	(0.005)
Income: Cultural landscape payments	0.005	0.002	0.004
	(0.004)	(0.004)	(0.004)
Income: Production system payments	0.003	−0.004	0.004
	(0.005)	(0.004)	(0.005)
Observations	582	582	582
Adjusted R^2	0.388	0.352	0.347
F Statistic	6.575***	5.789***	5.682***

Note: *, **, and *** denote statistical significance at the 10%, 5%, and the 1% levels, respectively. Standard errors are in parentheses. Reference groups of categorical variables: Agricultural zone: valley; Farm type: arable farming.

TABLE A3 | *t*-statistics of covariate mean comparisons between farms inside and outside parks.

Variable	*t*-statistic (park—non-park)
Farmer age	−0.38
Farmer education	−0.25
Information sources—conventional	
Cantonal extension service	0.98
Agricultural magazines	−2.89***
Colleagues	−0.14
Information sources—park-related	
Advisory project	1.60
Nature conservation organizations	−0.17
Norms regarding biodiversity	
Personal norm	1.59
Injunctive norm—family	1.33
Injunctive norm—acquaintances	0.76
Descriptive norm—other farmers	1.30
Self-efficacy regarding biodiversity	
Self-efficacy—personal skills	2.46**
Self-efficacy—damage prevention	0.26
Self-efficacy—overcoming difficulties	0.92
Attitudes—pro-production	
Agricultural policy-income	−0.10
Agricultural policy-self-sufficiency	−1.18
Attitudes—pro-environment	
Agricultural policy-biodiversity	1.43
Agricultural policy-environment	−0.76
Income sources (production)	
Farm sales	0.38
Food security payments	0.82
Off-farm	−1.23
Income sources (conservation)	
Biodiversity payments	2.99**
Cultural landscape payments	3.13***
Production system payments	1.70*

(Continues)

TABLE A3 | (Continued)

Note: *, **, and *** denote statistical significance at the 10%, 5%, and the 1% levels, respectively.

TABLE A4 | Coefficient estimates of park on AES adoption based on optimal pair matching.

	Action-based		Result-based		Agglomeration	
Model	**Base**	**Full**	**Base**	**Full**	**Base**	**Full**
Park	0.037*** (0.014)	0.007 (0.015)	0.040*** (0.011)	0.009 (0.011)	0.058*** (0.014)	0.013 (0.015)
Adj. R^2	0.007	0.31	0.014	0.32	0.018	0.27
N	917					

Note: *, **, and *** denote statistical significance at the 10%, 5%, and the 1% levels, respectively. Standard errors are in parentheses.