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D4.4 Systematic analysis of the case studies

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Systematic analysis of the case studies

Deliverable D4.4

31 March 2023

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BESTMAP

Behavioural, Ecological and Socio-economic Tools for Modelling Agricultural Policy

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Table of contents

Preface

This deliverable presents a comprehensive synthesis of the main findings obtained for each of the project's five case studies (CS). Specifically, it provides a systematic overview of the main results covering (1) the information from farmers gained from the interview campaigns and (2) online questionnaire, (3) identification of farming system archetypes, (4) biophysical modelling of biodiversity and ecosystem services, and (5) agent-based modelling. The document is structured into five chapters, with each section outlining the general approach to analysis, the main findings for each CS and a summary of the similarities and differences among case studies.

Summary

This document provides a summary of the systematic analyses conducted across BESTMAP five CS as part of the activities in Work Packages (WP) 1, 2, 3 and 4. First, we describe the main qualitative findings obtained from farmers during the semi-structured interview campaigns regarding their attitudes towards the implementation of agri-environmental schemes (AES). Second, we elaborate on the results from the follow-up online questionnaire which included the Discrete Choice Experiment (DCE) to investigate farmers' personal views, socio-economic background and especially their preferences for specific AES contract characteristics which were subsequently used to inform the parameterization of CS agent-based models (ABMs). Third, we summarise the similarities and differences in the types of farms that occur in each CS, using the Farming System Archetypes typology based on several categories of farm specialisation and economic size. Fourth, we quantify the main results of the biophysical models of WP3 tailored specifically for each CS, comparing the values of biodiversity and ecosystem services calculated for the scenario of the current AES implementation with ecosystem service values calculated for a scenario simulating no AES adoption. Finally, we synthesise the main findings of the ABMs developed in WP4, specifically investigating the effects of four AES policy scenarios (advisory support, high payment rates, short contracts and low bureaucracy) as compared to the status-quo scenario of the current AES adoption rates.

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1. Information from farmers (interview campaigns)

1.1. Approach

BESTMAP semi-structured farmer interview campaigns were carried out in 2020 to obtain data on farmers' decision-making regarding agri-environmental schemes (AES). The campaigns were designed following a methodology based on exploratory qualitative research. A common protocol was developed for the case study interview campaigns, consisting of open-ended questions on the farmer's background, attitudes towards farming, reflection on ecological aspects of farming and, in particular, reasons for their (not) participation in AES. The recorded interviews were transcribed, and data analysis was performed based on a coding frame previously defined for qualitative content analysis, which considered a combination of deductive and inductive categories - concept-driven categories. The analysis was performed using computer-assisted data analysis software (CAQDAS) to ensure sensible data management and analysis. Qualitative content analysis is a method designed to systematically reduce and interpret qualitative data that can help to deal with some of the challenges listed above. More details on the interview campaign can be found within Deliverable D3.4 "Summaries of data, obstacles and challenges from interview campaigns". The resulting information is gathered to inform the agent-based models (ABM).

In order to organise the comparative analysis results and their discussion, we used a conceptual framework (Figure 1) based mainly on Gütschow et al. (2021), Paulus et al. (2022) and Wittstock et al. (2022).

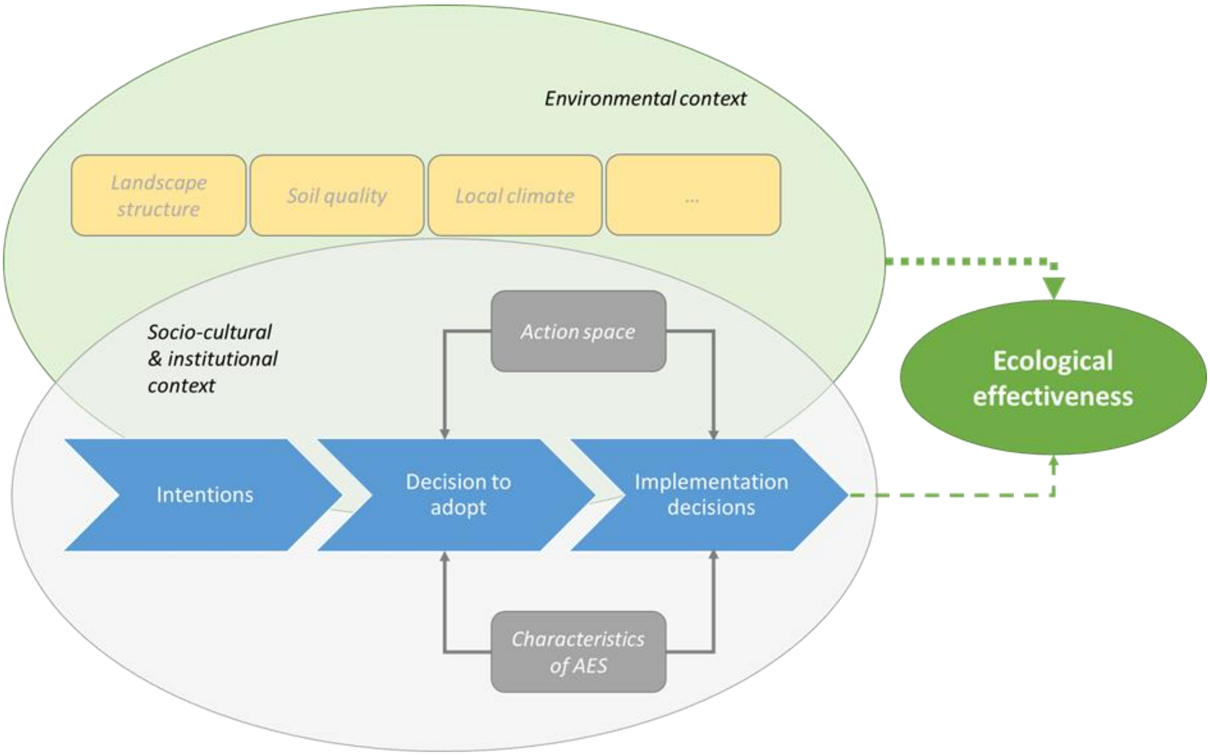

Figure 1: Diagram of the conceptual framework for the comparative analysis of qualitative insights into determinants of AES adoption (Source: BESTMAP, own work).

1.2. Similarities and Differences among case studies

Summary of the results of the qualitative content analysis is presented in this section that focuses on the similarities and differences in responses among all the case studies. It has been divided according to the 9 categories defined in the conceptual framework shown in Figure 1. These are:

- Economic considerations (opportunity costs)
- Fit with established practices
- Bureaucracy load
- Flexibility of schemes
- Advisory services
- Tenure
- Farm size and organisation
- Trust in and support for policy and administration
- Intrinsic motivation and environmental effectiveness

Results of the analysis include a list of the elements that farmers expressed in all case studies (common to all CS) to easily identify what concerns, practices and beliefs are transversal across European farmers. It also includes specific singularities (differences across CS) and highlights related to the 9 categories that characterise each Case Study in particular. Finally, for each category and case study, a level of importance (0 low importance - 5 high importance) is included. This indicator was extracted from the qualitative analysis based on the perception collected by the interviewers during the interviews and also the number of times a category was mentioned by all the farmers interviewed at each CS.

1.2.1. Economic considerations (opportunity costs)

Common elements
• AES are adopted when the loss of income is negligible • Farmers receive payments for practices they were adopting/going to adopt anyway. • Payments are a source of additional income when there is marginal land that can be easily enrolled in the AES. • AES are adopted on the basis of their implementation and opportunity costs rather than expected environmental effectiveness. • The adoption of AES is driven by cost-benefit analysis. This is especially true for more environmentally ambitious AES, which usually involve higher costs. • Often, AES payments barely cover the costs of their implementation. • In the case of result based schemes, farmers are sceptical because of the risk of investing without reward or being fined, due to external factors beyond their influence.
Singularities and highlights
Humber (UK) - Importance *level: 5*
- In general, the economic compensation is considered sufficient, although not strictly profitable for most family-sized farms. In the case of farms located on highly productive land, AES participation is considered a loss of potential income. - The common element of financial compensation that can make the less productive areas of the field somewhat profitable is particularly relevant.

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Catalunya (ES) - *Importance level: 5*
- In general, farmers consider that payments are too low to transform current practices, as these cover only a small part of the cost. - The decision to adopt environmental measures is not influenced by the subsidies but motivated by a reorientation of the business to increase the added value of the product and adapt to new market demands (especially in the case of organic farming).
Mulde (DE) - *Importance level: 5*
- AES can make less profitable pieces of land more economically viable.
South Moravia (CZ) - *Importance level: 5*
- The economic benefit of AES is more significant for agribusiness farmers than the ones practising organic agriculture. - Farmers do not want to adopt measures that would not sufficiently compensate them for the loss of income.
Bačka (RS) - *Importance level: 5*
- Many farmers said that they would have no capacity to cope with further financial losses, as they are already working with minimal profit or sometimes even losses - Farmers with higher education level, younger farmers, farms with additional incomes and organic producers more often expressed readiness to consider implementing AES to preserve the environment, in some cases even with decrease or loss of direct short term profit. - The common element of financial factors having the highest priority in farmers' decision making is particularly relevant.

1.2.2. Fit with established practices

Common elements
● Farmers may have land on which they know the requested species already exist. ● If AES are well matched or close to factors related to the farmer's routine, they adjust their practices (little effort) to apply for the corresponding payments.
Singularities and highlights
Humber (UK) - Importance *level: 5*
- Changes in current farming practices can still be contemplated by farmers, provided the economic compensation is attractive.
Catalunya (ES) - *Importance level: 5*

- Farmers apply AES when the change also provides a benefit to farm sustainability (i.e. soil fertility). - AES requirements sometimes don't match the crop management rationale. - AES are not considered when these require relevant changes in workflow and unknown practices as they generate too much uncertainty. - Farmers are not able to take the risk of losing the harvest and reduce the yield because of a given AES.
Mulde (DE) - Importance *level: 5*
- AES only plays a minor role in their overall farming activities. Farmers say that it is nice to have AES for various reasons, but they are not essential. - Decision-making on AES is not different from any other land-use decision-making on the farm. - AES can contradict or complicate established farm practices.
South Moravia (CZ) - *Importance level: 4*
- The common element of AES requirements should be close to farmer's routines is the most relevant in this case study.
Bačka (RS) - *Importance level: NA*
- To be evaluated when AES will be implemented

1.2.3. Bureaucracy load

Common elements
• Farmers express reluctance to run the risk of not receiving (part of) the payment for minor violations of AES conditions. • The bureaucratic requirements are not only perceived as undermining farmer autonomy and distrust in the farmer's expertise but may also exacerbate inequalities by favouring large farms that can afford to pay someone to handle AES administration. • Farmers tend to adopt easy-to-implement AES with minimal additionality
Singularities and highlights
Humber (UK) - Importance *level: 5*
- Farmers express lack of time or resources to understand how to apply for a scheme and what are the different options within the schemes.
Catalunya (ES) - *Importance level: 4*
- Farmers express that the bureaucracy of AES requires a lot of dedication and time that they do not have, so they delegate the management of subsidies to an agency or advisory body.
Mulde (DE) - *Importance level: 3*

- Farmers are well informed about AES, but small farms usually do not have the resources to spend too much effort on the administrative part of AES.
South Moravia (CZ) - Importance *level: 2*
- All farmers criticise the bureaucratic burden, which is even more pronounced in the case of smaller farms, which do not have such a large administrative capacity.
Bačka (RS) - *Importance level: 4*
- Farmers report a general lack of information on environmental issues and on potential programs to support environmental practices.

1.2.4. Flexibility of schemes

Common elements
• Farmers often consider AES as inflexible, restrictive and undermining the farmer's decision-making autonomy. • AES are not context-specific and are therefore not relevant to the particular situation of their farms.
Singularities and highlights
Humber (UK) - Importance *level: 4*
- Farmers are keen on seeing an increased flexibility than what is currently offered by the schemes. - They are wary of result based schemes and afraid of being fined. - Farmers report lack of flexibility of the schemes and the fear of an increased scrutiny of the government on individual farms' practices.
Catalunya (ES) - *Importance level: 2*
- Some farmers believe it would be good to differentiate the amount of subsidies for some measures (such as organic farming) according to the area. - Farmers are concerned that the limited flexibility of the measures will significantly increase the risk of profits in the event of exceptional situations.
Mulde (DE) - Importance *level: 3*
- Farmers believe that incentives often contradict sustainable practices.
South Moravia (CZ) - Importance *level: 2*
- Farmers say that the payment per hectare should be better developed for grassland management.

Bačka (RS) - Importance *level : NA*
- Farmers say criteria for some programs are too strict and have uncertain benefits

1.2.5. Advisory services

Common elements
● Advisory services, which lie at the boundary between the action space and AES design characteristics, were mentioned in some CS as a facilitating factor, even though the particular advisory contexts differ strongly from one another.
Singularities and highlights
Humber (UK) - Importance *level: 2*
- Farmers complaining about the loss of consultancy service due to the change of management AES from a personalised approach (Natural England) to a computerised system. Currently only an automated system is available by the Rural Payment Agency.
Catalunya (ES) - *Importance level: 3*
- Farmers consider that there is a strong advisory system in place.
Mulde (DE) - Importance *level: 3*
- Farmers consider that advisory services are inadequate.
South Moravia (CZ) - Importance *level: 2*
- Farmers consider that advisory services are inadequate.
Bačka (RS) - Importance *level: 3*
- Farmers consider that advisory services are inadequate. - Farmers complain about high fees for consultancy.

1.2.6. Tenure

Common elements
● Tenure security is a relevant parameter for farmers, as are landlord-tenant relations.

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Singularities and highlights
Humber (UK) - Importance *level: 2*
- Landlords are reported to be a driving force behind the adoption of AES, although long-term tenure (contracts ps severañ decades) is not uncommon. - Trade off: farmers physically cultivate the land and make profits through production, large estate owners (landowners) make profit by renting the land and also benefit from the implementation of schemes around the fields. - The farm is governed by two factors: one directly linked to intensive farming for profit, and the other benefiting from the extensive application of AES.
Catalunya (ES) - *Importance level: 1*
- Some farms/farmers are organised in / part of cooperatives and do not participate directly in the selection and administration of the AES selection. - The delegation of administrative tasks from AES to third parties is common.
Mulde (DE) - *Importance level: 3*
- Landlords are perceived as sceptical of or even “not understanding” AES, which makes the farmers think twice before they adopt a scheme. - In many cases easily reversible AES are adopted. i.e. conversion of arable land into grassland as part of an AES is only minimal, as it is legally prohibited in Germany. - Long-term obligations overrule short-term AES funding periods.
South Moravia (CZ) - *Importance level: 2*
- Farmers prefer long-term AES, provided that farmers have correspondingly long-term tenure contracts (80% of the farmers manage leased farmland, while only about 20% are owners).
Bačka (RS) - *Importance level: 5*
- The State is a major landowner and short-term contracts are common. Renting state-owned land is discouraging and only minimal and easily reversible AES will be adopted. - The new regulations only allow annual contracts for renting state-owned land, and farmers have no guarantee that they will be able to rent the same parcel the following year, so they have no incentive to conserve or invest in the quality of soil.

1.2.7. Farm size and organisation

Common elements
● In general, there are differences between small and large farms when it comes to adopting AES, both in terms of economic and scheme-related aspects.
Singularities and highlights

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Humber (UK) - Importance *level: 4*
- Family-run farms perceive AES as a steady, albeit low, income for the less productive parts of their land, and/or as a contribution to major maintenance works on farm buildings. - Farmers see AES as a potential contribution to the resilience of their food production system. - Large family-owned farmers may benefit more from AES, as they cover (much) larger areas and have the resources to hire staff to manage/apply the schemes. - Some farmers are less motivated by the potential contribution of certain AES to increasing productivity of their land, as the arable land is usually rented to external contractors.
Catalunya (ES) - Importance *level: 3*
- Farmers express that geographical location of AES is key, and beneficial when matching with protected areas. - Some of the farmers indicate that size is not relevant since they are part of a cooperative and certain practices are determined by the cooperative. Similarly, there is total delegation of decision making to the cooperative's technicians.
Mulde (DE) - *Importance level: 4*
- Farmers express that there is a difference between small and larger farms. For small farms it might be an essential economic contribution to their farm income.
South Moravia (CZ) - *Importance level: 2*
- Farmers of small enterprises, such as those specialised in integrated vegetable production, report having difficulties in obtaining AES because they do not reach the minimum area required..
Bačka (RS) - *Importance level: 3*
- Farmers express that the ability to adopt AES and thus receive additional funding would likely be related to farm size and organisation, which could exacerbate already existing conflicts between small and large farms. - Younger and more educated farmers have a better understanding of the indirect benefits of participating in AES and a willingness to learn and implement new techniques.

1.2.8. Trust in and support for policy and administration

Common elements
• In general terms the policy objectives are considered positive, but farmers are sceptical about the implementation conditions and control mechanisms in place.
Singularities and highlights
Humber (UK) - Importance *level: NA*

- Farmers have a positive perception of the subsidy system and the current agricultural policy framework.
Catalunya (ES) - *Importance level : NA*
- The agricultural policy framework was viewed positively by most interviewees.
Mulde (DE) - *Importance level : NA*
- Scepticism towards the CAP in general was pronounced among the farmers interviewed.
South Moravia (CZ) - Importance *level : NA*
- Farmers expressed a general scepticism towards the state's involvement in agriculture. - Farmers are acquainted with the structure of agri-environmental measures through various training and materials of agricultural agencies. - Farmers would prefer to have greater involvement in decision making. - Farmers comment that there is a sophisticated system for receiving applications for AES and a follow-up control system in place, but they wish for better design of measures.
Bačka (RS) - *Importance level : NA*
- Farmers express fear of corruption as a reason for scepticism towards agricultural policy, including AES. - Farmers believe that laws and regulations are not sufficiently respected, and that there is ineffective enforcement of the law by institutions. - Farmers believe that there is a lack of an external agency to coordinate joint efforts. - Lack of state support to create a predictable, reliable and fair system for agriculture.

1.2.9. Intrinsic motivation and environmental effectiveness

Common elements
● Intrinsic motivation and attention to environmental effectiveness was a surprisingly little pronounced factor in most CS regions.
Singularities and highlights
Humber (UK) - *Importance level: 3*
- Farmers are aware to a reasonable degree of the importance of environmental practices on farmland, and the vast majority of farmers adopt some environmentally friendly practices. - Farmers want to improve resilience and soil health to maintain long-term productivity. - All farmers that did not participate in AES still expressed positive thoughts towards wildlife.
Catalunya (ES) - *Importance level: 2*

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- Farmers' intrinsic motivation may be undermined by scepticism about the environmental effectiveness of AES. - Farmers who do not apply for AES are aware of the potential of the environmentally sustainable practices and apply them, especially in terms of improving soil quality because it has a direct impact on higher productivity.
Mulde (DE) - *Importance level: 2*
- Many farmers are carrying out practices that are environmentally friendly without applying for AES.
South Moravia (CZ) - *Importance level: 3*
- Farmers' motivation is very much linked to the scheme's duration; farmers prefer longer contracts. - Farmers believe in the need for more detailed monitoring of environmental related impacts and opportunities for AES in relation to landscape connectivity..
Bačka (RS) - *Importance level: 3*
- Farmers recognize the importance of sustainable production, which ensures the preservation of the productive potential of the land in the future and the health of the population. - Small and medium-sized family farms that use environmentally harmful practices have no choice and blame the government or local authorities for lack of organised support for more sustainable options.

1.3. Reasons for AES (non) participation per case study (BB + CD) (summary section 3.1.2 D3.4)

UK

The main reason for farmers' participation in AES was that the particular AES fits well or is close to already established practices, so the farmers only adjust their current practices or directly apply for the corresponding payments but also because they are motivated by knowing that they do something positive for biodiversity and/or the environment (occasionally motivated by hunting).

In contrast, the main reasons for AES non-participation were following:

- Lack of flexibility of the schemes and the fear of an increased scrutiny of the government on individual farms' practices
- Lack of time or resources to understand how to apply for a scheme and what the different options are within the schemes.
- AES do not provide surplus income for land earmarked for them; for farms on highly productive land, participation in AES is seen as a loss of potential income.

ES

The main reasons for ES farmers to participate in the AES are related to the fact that the farming system they already do fits well or is close to the practice required by the scheme.

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Additionally, farmers are quite concerned about the sustainability of their practices or are part of a cooperative that determines some types of practices related to AES. Finally, some farmers are motivated to adopt AES that help them increase the added value of the product and adapt to new market demands, reorienting their business (i.e., organic farming).

Most important reasons for AES non-participation were related to:

- AES requirements are too different from the family traditional business model of the farm and therefore, there is more resistance towards change.
- Not enough economic compensation for the economic losses.

DE

Most important reasons for AES participation were related to the fact that AES offer the opportunity to economically exploit certain plots of land that could only be managed with a lot of effort or without economic benefit and that for certain fields and specific schemes, AES generates income or financial compensation without much added effort.

Most important reasons for AES non-participation were related to:

- the feeling that the application involves too much effort for too little money,
- to the low probability of AES acceptance participation due to low availability of AES because overbooking,
- to the fact that double funding from different subsidies for a same field is not allowed and many of themes are already included in Pillar 1
- due to insecurity about achieving the minimum outcomes required of result-based schemes.

CZ

The main reason for CZ farmers to participate in the AES is economic compensation although they are also concerned about its positive impact on the environment.

Contrary, most important reasons for AES non participation were related to:

- Strict requirements such as required minimum area.
- Insufficient economic compensation for the loss of income.
- Perceived bureaucratic burden.

RS

In this case study reasons for AES participation or not were discussed hypothetically. Farmers expressed their willingness to participate depending on the conditions of the particular schemes. They specifically indicate that the economic compensation is an important reason, because they are already working with minimal profits, and they were also concerned about the complexity level of the administrative procedures.

2. Information from farmers (online questionnaire and Discrete Choice Experiment)

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2.1. Approach

Despite the quantitative component, our interview campaign provided limited information to parameterize the agent-based model (see Section 5) and infer differences in behaviour between farmer types. Therefore, we decided to conduct a follow-up online survey consisting of mostly closed-ended questions and a discrete choice experiment (DCE) (see Deliverable D1.8 for the complete questionnaire). With the survey, we covered in particular farm characteristics (including questions on the specialisation of the farm), personal values (covering questions on attitudes towards the environment, societal influence and exchange with other farmers) and socio-demographic questions. In addition, we included experience with existing AES and asked for reasons why farmers did or did not participate in specific schemes. The main objective of the DCE was to investigate the preferences of farmers across case studies for a selection of agri-environment contract characteristics.

The design of the questionnaire and the DCE was pretested with 13 completed questionnaires from the five CS collected between September and October 2021. Data collection in the four case studies took place between September 2021 and April 2022.

Overall, we obtained 381 usable responses across four of the five case studies (CZ: 69, DE: 74, RS: 131, UK: 107) (see Deliverable 1.8 for more details on how the responses were collected). For ES, we received only 22 completed responses which we decided not to evaluate due to lack of representativeness. Figure 2.1 shows the geographical distribution of the survey participants.

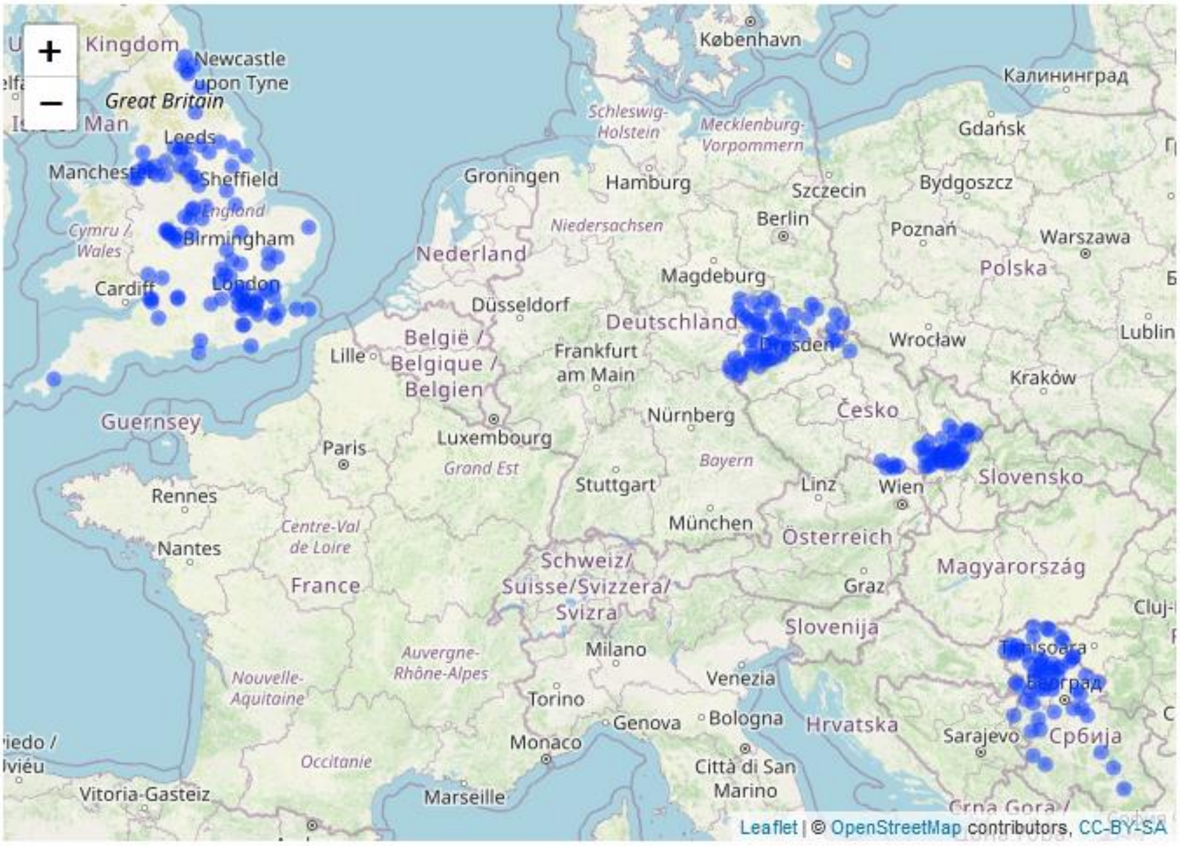

Figure 2.1: Geographical distribution of the survey participants across the case studies. Respondents

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in Catalonia are not covered on the map since we did only ask for the municipality they are located in and did not further specify the postcode.

Across case studies, the sample consisted of mainly full-time individual or family-run farms (Figure 2.2). This was particularly pronounced in the UK where only a few part-time farms and company owned farms are covered in our sample. In Serbia, the share of full-time and part-time farmers is almost equal. In Germany and the Czech Republic, a substantial proportion of farms is company owned or a cooperative of farms.

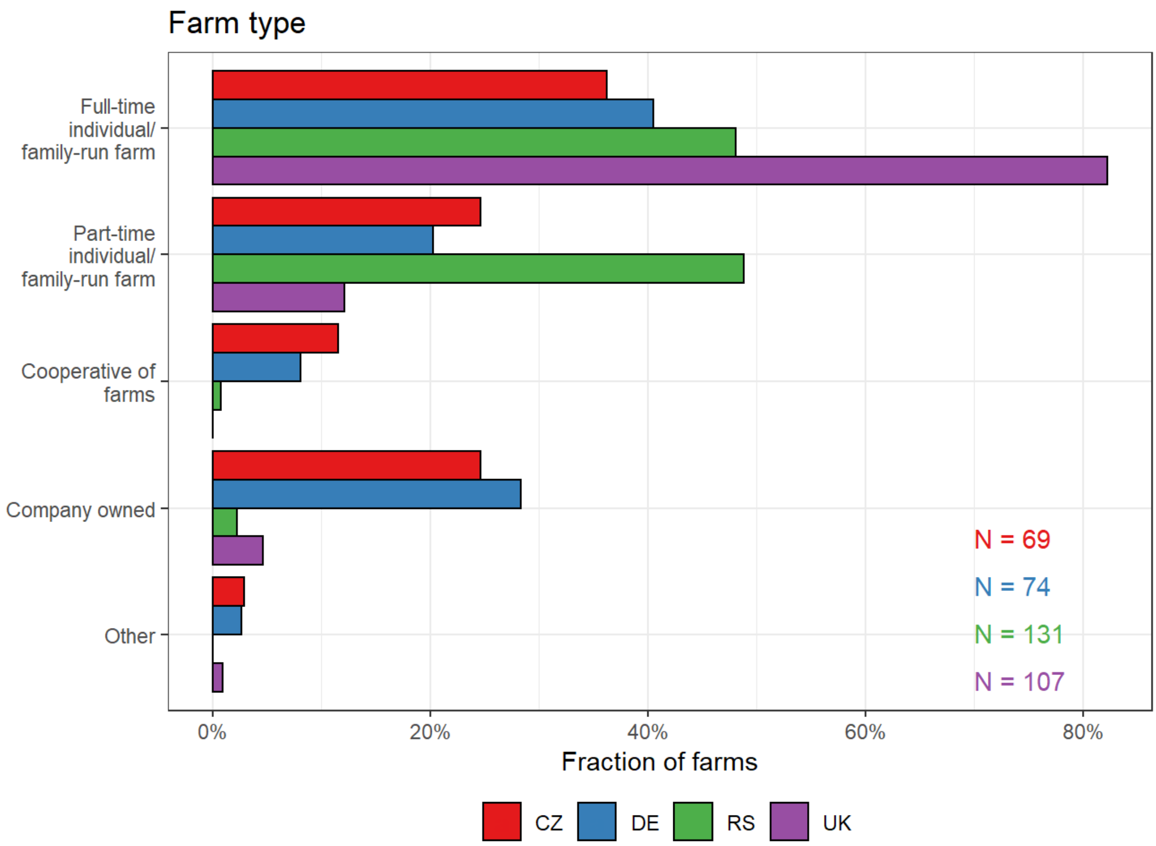

Figure 2.2: Distribution of farm types across the sample in the different case studies.

Across case studies, we have reached mostly young to middle-aged farmers with peaks between 35 and 44 years for three of the four case studies (Figure 2.3). Only in Germany, most farmers in our sample are slightly older (45-54 years).

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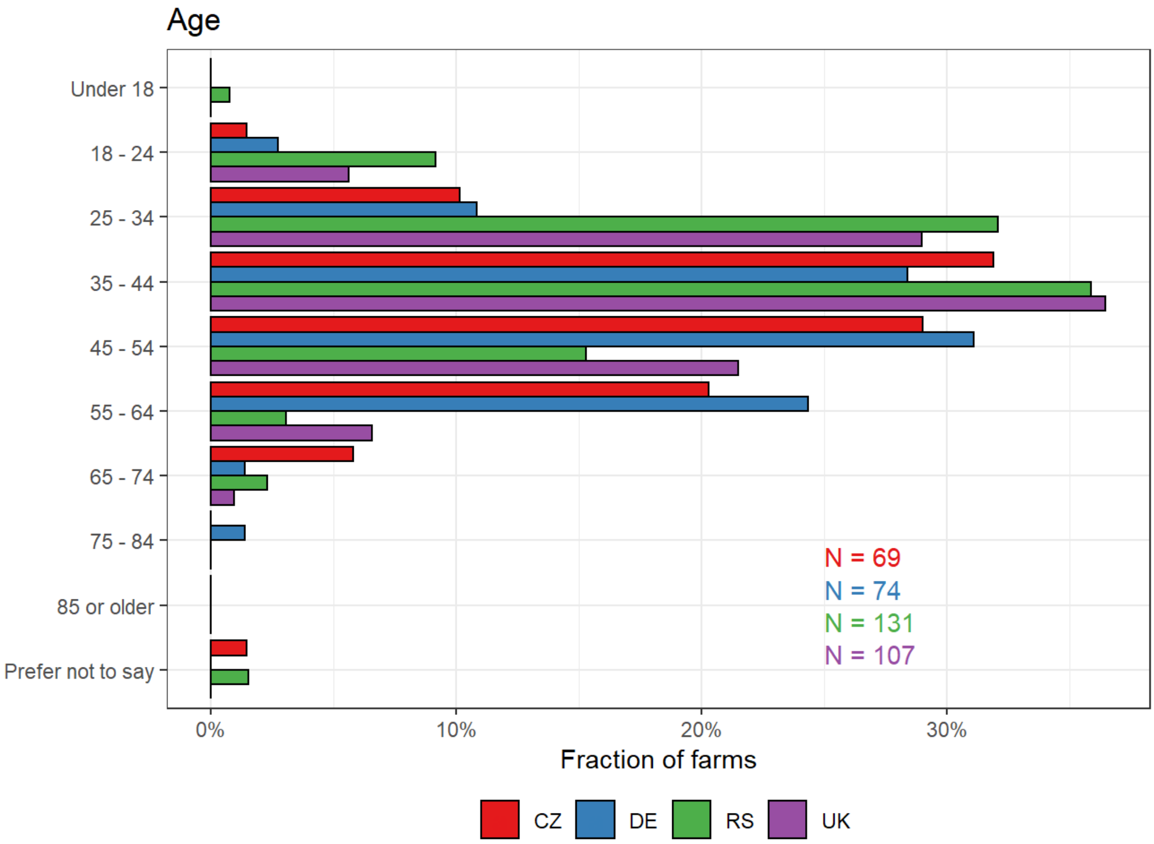

Figure 2.3: Age distribution across the sample in the different case studies.

2.2. Discrete choice experiment

The main objective of the discrete choice experiment (DCE) was to investigate the preferences of farmers across case studies for a selection of agri-environment contract characteristics. Respondents had to choose in six repeated choices between four alternative AES and a "no scheme" option where farmers would not get any funding for agri-environmental practices. In addition to the offered payment level, we chose contract length, bureaucratic effort and advisory support as key attributes to be varied between the schemes. An example of a choice card (for the UK CS) can be seen in Figure 2.4. Each DCE was presented in a unique way in each CS and the framing was tailored to AES that participants were already familiar with (e.g., in the UK the contracts were presented as Countryside Stewardship-offered contracts) while stressing the hypothetical nature of the options.

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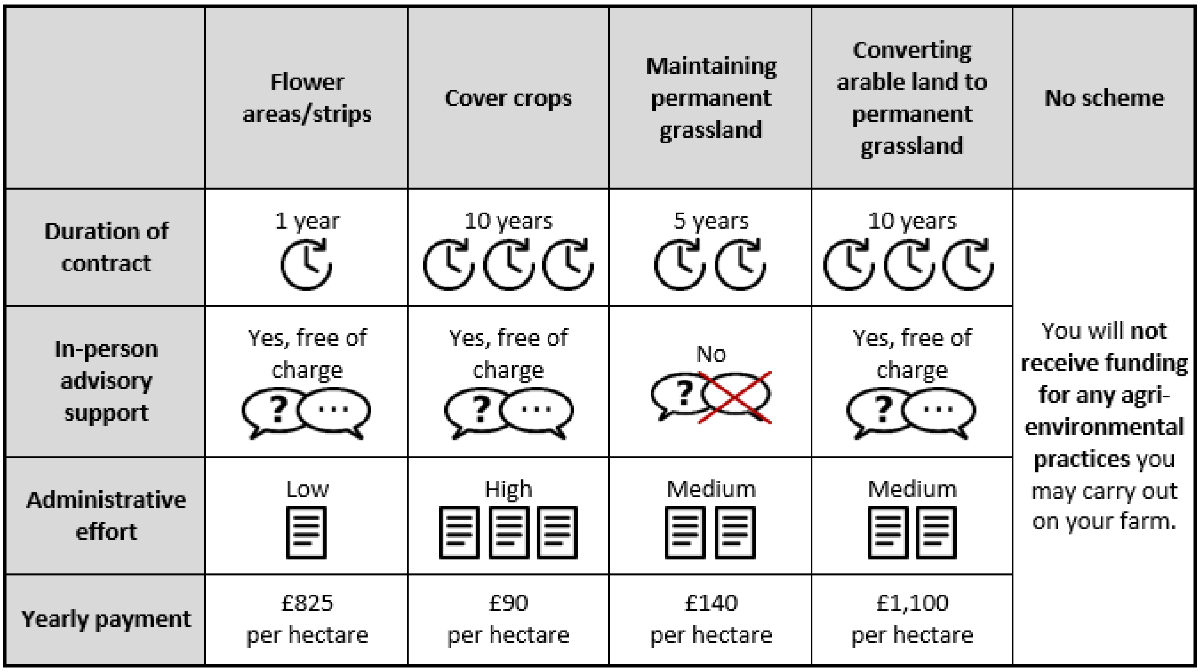

	Flower areas/strips	Cover crops	Maintaining permanent grassland	Converting arable land to permanent grassland	No scheme
Duration of contract	1 year	10 years	5 years	10 years	You will not receive funding for any agri-environmental practices you may carry out on your farm.
In-person advisory support	Yes, free of charge	Yes, free of charge	No	Yes, free of charge	
Administrative effort	Low	High	Medium	Medium	
Yearly payment	£825 per hectare	£90 per hectare	£140 per hectare	£1,100 per hectare	

Figure 2.4: Example of a choice card from the UK survey scheme. Farmers had to choose between one of the four offered schemes that differed in contract characteristics (duration of contract, advisory support, administrative effort and yearly payment) and a 'no scheme' option.

The results from a Mixed Logit Model with no interaction with other non-contract variables are presented in Table 2.1, along with the willingness to accept (WTA). WTA is the ratio of an attribute's coefficient over the mean compensation, estimated through a distribution (in our case normal over log-normal). By default, such estimates can take both negative and positive values. Following Ruto and Garrod (2009), negative values are interpreted as farmers requiring compensation (per hectare, per year) for accepting less desirable contract features while positive values are interpreted as the discount (per hectare, per year) that farmers are willing to provide if desirable contract characteristics are available in an offered contract. From the results there is no attribute non-attendance across the models as different contract features are statistically significant in different models. Table 2.1 presents estimates and WTA for Germany, Czech Republic, the UK and Serbia. Four alternative-specific constants (ASCs) were inserted in the model to capture preferences and the WTA for enrolling in each of the four different contract types (FLOWER, COVER, GRASS and ARB_GRASS for flower area/strips, cover crops, maintaining grassland and converting arable land to grassland, respectively). All contract characteristics were considered to follow a normal distribution apart from compensation which followed a log-normal one. Reported compensation estimates refer to the mean estimate of the logarithm.

Table 2.1: Coefficients and marginal rate of substitution (WTA) for contracts and contract characteristics. ɣ: converted in Euros; □ mean log value, ***, **,* denote statistical significance at the 1%, 5% and 10% level respectively.

	Germany		Czech Republic		United Kingdom		Serbia	
Choice	*Coeff*	*WTA*	*Coeff*	*WTA*	*Coeff*	*WTAɣ*	*Coeff*	*WTAɣ*

FLOWER	-0.579 (0.410)	-280.59* (156.19)	3.247*** (0.464)	-140.66* (73.42)	0.388* (0.232)	412.41 (276.20)	-2.398*** (0676)	-441.35*** (126.58)
COVER	-0.242 (0.195)	-117.08 (94.81)	0.603** (0.298)	-26.12 (17.43)	1.060*** (0.192)	1127.10*** (318.81)	-0.133 (0.335)	-24.52 (61.09)
GRASS	-0.253 (0.228)	-122.72 (102.10)	2.478*** (0.328)	-107.32** (53.44)	0.592*** (0.200)	629.60** (256.44)	-1.378*** (0.253)	-253.67*** (64.02)
ARB_GRASS	-4.250*** (0.878)	-2059.38*** (242.05)	3.547*** (0.590)	-153.65* (85.55)	-0.350 (0.326)	-371.92 (328.30)	-3.046*** (0.600)	-560.68*** (132.11)
CONTRACT1	0.520*** (0.182)	251.72*** (100.50)	-0.325 (0.250)	14.09 (13.18)	0.024 (0.132)	25.29 (140.24)	-0.279 (0.195)	-51.29 (36.72)
CONTRACT10	-0.814*** (0.247)	-394.59*** (149.22)	-0.427 (0.302)	18.51 (16.02)	0.048 (0.120)	50.80 (127.33)	-0.291 (0.182)	-53.57 (35.15)
SUPPORT	0.202 (0.198)	98.03 (99.25)	-0.286 (0.348)	12.39 (15.94)	0.394*** (0.133)	419.15*** (166.81)	0.183 (0.249)	33.76 (46.08)
ADMIN_LOW	0.265 (0.226)	128.24 (116.90)	-0.675*** (0.290)	29.25 (18.93)	0.052 (0.133)	55.31 (141.55)	-0.174 (0.172)	-32.09 (31.58)
ADMIN_HIGH	-0.719*** (0.261)	-348.40** (142.86)	-0.676* (0.409)	29.27 (22.31)	-0.080 (0.141)	-84.79 (151.20)	0.078 (0.247)	14.32 (45.44)
COMPENSATION	0.002*** (0.001)	-	0.023** (0.011)	-	-0.001*** (0.001)	-	0.010 ** (5.290)	-
St. Deviations								
CONTRACT1	0.611** (0.265)	-	-1.021*** (0.330)	-	-0.385* (0.215)	-	1.022*** (0.252)	-
CONTRACT10	0.908*** (0.297)	-	-0.811** (0.328)	-	0.435** (0.200)	-	0.674*** (0.259)	-
SUPPORT	0.602** (0.247)	-	-0.665 (0.434)	-	0.613*** (0.219)	-	1.104*** (0.232)	-
ADMIN_LOW	0.440 (0.353)	-	-0.574 (0.387)	-	0.029 (0.307)	-	-0.372 (0.380)	-
ADMIN_HIGH	-0.352 (0.351)	-	-1.068** (0.433)	-	0.573*** (0.201)	-	0.141 (0.379)	-
COMPENSATION´	0.003*** (0.001)	-	0.152 (0.167)	-	0.001*** (0.001)	-	0.100* (0.058)	-
Observations	74		69		107		104	

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Pseudo R-squared	0.06	0.14	0.03	0.09
BIC	1303.311	1197.367	2022.038	1756.148
Log-likelihood	-605.90293	-627.4418	-978.50387	-866.37205

Farmers have mostly uniform preferences for contracts and their characteristics as can be seen by the similar signs in contract characteristics across countries in Table CI. Existing agri-environment contracts (flower strips, cover crops and maintaining grasslands) were well-perceived by participants while the more innovative and commitment-intensive scheme of converting arable land to grassland was less desirable. 10-year contracts are less preferred than 1-year contracts, when compared to the baseline which showcases an aversion towards long-term commitment to agri-environmental activities. The provisioning of advisory support uniformly decreases the requested compensation across all countries. Bureaucracy and scheme complexity are considered by farmers as large deterrents when considering AES enrolment.

2.3. Similarities and Differences

In this section, we characterise the main similarities and differences in the personal views and sociodemographic background of farmers (for CZ, DE, UK, ES, RS) and their tendency to adopt different AES (for CZ, DE, UK, ES). To make and address meaningful comparisons, only questions answered by all five (four) CS were included, excluding open-ended (text) responses. We also excluded the CS of Serbia (RS) from AES-related questions (part 2.3.2) due to the discrepancy in question form with the other four CS and neglected the first part of the survey (farm characteristics) because the questions in the RS CS did not match the remaining ones. After reducing the number of variables, we performed a Kruskal-Wallis test by rank given the non-normal distribution of our data. This is a non-parametric alternative to one-way ANOVA test and extends the two-samples Wilcoxon (Mann-Whitney U test) in the situation where there are more than two groups. We restricted our focus to variables for which significant differences are observed (Figures 4 and 5) and drew inferences even from variables for which response rates were low (10–20%).

2.3.1. Personal views and sociodemographic background

Table 2.2: Central tendencies of research questions (variables) including personal views (Q8) and sociodemographic background (Q9) expressed as arithmetic mean at CS level (rows from top to bottom: CZ, DE, UK, ES, RS). NA values are excluded.

	Q8.1 A1	**Q8.1 A2**	**Q8.1 A3**	**Q8.1 A4**	**Q8.1 A6**	**Q9.1**	**Q9.2**	**Q9.3**	**Q9.6**	**Q9.8**
CZ	2.7	1.8	3.3	1.6	2.2	21.5	3.8	2.4	1.8	4.8
DE	3.1	1.7	3.2	2.1	2.5	22.7	3.8	2.4	1.6	4.7
UK	2.2	1.9	2.2	1.9	2.0	15.2	2.8	1.7	2.7	4.0
ES	3.1	1.8	2.8	1.7	1.9	23.2	2.3	2.1	1.8	4.9
RS	2.2	1.6	2.5	2.3	2.2	16.6	2.5	1.7	1.9	3.8

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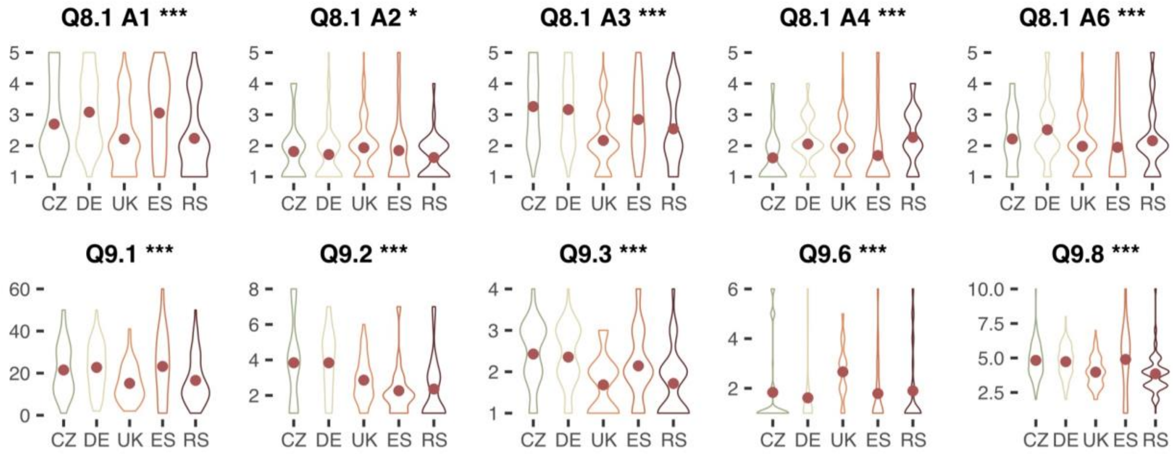

Q8 Personal views *1 fully agree – 5 fully disagree*
Q8.1 A1 *Achieving a good quality of life is more important to me than maximizing income from farming.*
Q8.1 A2 *Protecting the environment is an important task for farmers.*
Q8.1 A3 *Food production is the only goal of agriculture.*
Q8.1 A4 *It is important that farming is perceived by society as environmentally friendly.*
Q8.1 A6 *We like to use new technologies as they become available.*

Q9 Sociodemographic background
Q9.1 *How many years in total have you been working in agriculture? 0 yrs - 60 yrs*
Q9.2 *What is your highest level of education (in agriculture)? 1 low - 8 high*
Q9.3 *Do you already have a designated successor for your company? 1 yes - 2 not yet - 3 no - 4 other*
Q9.6 *How many of your products do you sell directly to consumers? 1 <10 %, 3 <50 %, 5 <90 %*
Q9.8 *How old are you? 1 <18 yrs, 5 <54 yrs, 8 <84 yrs*

Figure 2.5: Background information on farmers adopting AES (except section one – farm characteristics). Violin plots show statistically significant differences (*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$) in the responses obtained from farmers between the five case studies (CZ, DE, UK, ES, RS).

Our comparison of personal views across CS ($n = 5$) shows that regional differences are statistically significant for five of the six variables that we were able to mathematically process (Table 2.2 and Figure 2.5). Farmers in the United Kingdom and Serbia are far more interested in having a ‘good quality of life’ (score of ~2.2), whereas farm businesses in Spain and Germany tend to be more income-oriented and focused on profit (score of ~3.1). In contrast, respondents from the Czech Republic aim towards a balanced strategy, aiming for a reasonable ratio between leisure and work (score 2.7). While a *p*-value of around 0.04 shows statistical significance of the responses between CS, they all have comparable mean (~1.8) and low variability. This suggests a consistent agreement among farmers at the European level to protect the environment. In answer 3 (Q8.1), farmers on average gave somewhat contradictory reactions compared to the first answer. This is because practitioners in the UK, along with practitioners in Serbia, believe that the agricultural sector should be primarily responsible for food production regardless of other benefits. In contrast, the remaining Germany, Spain and the Czech Republic do not share a similar view (though we cannot elaborate on this comment given the limitations of the question to one response). Consistent with answer 2, and despite showing significant differences between case studies, farmers generally agree that their agricultural activities should be viewed as environmentally friendly, as evidenced by an average score of ~1.9 (Table 2.2 and Figure 2.5). With the exception of Germany, the Czech Republic and partly Serbia, which seem to be rather conservative in their

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adoption of new technologies (score ~2.3), the United Kingdom and Spain believe that their success depends on technological progress (score ~1.95).

In terms of socio-demographic background, the average length of experience in farming is around ~20 years, with the least and most experienced farmers working in the United Kingdom (15 yrs) and Spain (23 yrs) respectively. The length of experience of around 20 years corresponds with the average age of respondents being around 50 years (oldest in Spain, youngest in Serbia). The most 'agriculturally educated' farmers live in the Czech Republic and Germany (score of ~3.8), while in the United Kingdom, Spain and Serbia the sector is dominated by less educated individuals (score of ~2.5). The United Kingdom and Serbia are also more likely to plan ahead as a relatively high proportion of farmers know their successor (score of ~1.7). Farmers in the Czech Republic, Spain and Germany have less specific outlook in leading their companies (score of ~2.3. The United Kingdom is also the leader in the proportion of products sold directly to the customer, i.e. without intermediaries (score of 2.7), while the remaining countries/case studies have a steadily low number of direct buyers (score of ~1.8).

2.3.2. Adoption of agri-environmental schemes

Table 2.3: Central tendencies of research questions (variables) including adoption of different AES expressed as arithmetic mean at CS level (rows from top to bottom: CZ, DE, UK, ES). NA values are excluded.

	MG1	MG1 A1	MG5	MG6	FS1	FS1 A1	FS5	CC1	CC1 A1	CC5	Q7.1
CZ	1.9	70.7	1.4	1.5	2.7	1.0	1.1	2.7	1.6	1.2	2.0
DE	2.0	9.3	1.2	1.4	2.0	14.2	1.2	2.3	45.2	8.0	1.5
UK	2.4	49.2	1.6	1.2	2.2	77.8	1.6	2.3	54.8	3.5	2.0
ES	2.9	12.0	1.5	1.9	2.0	32.4	1.2	2.9	NA	1.4	2.2

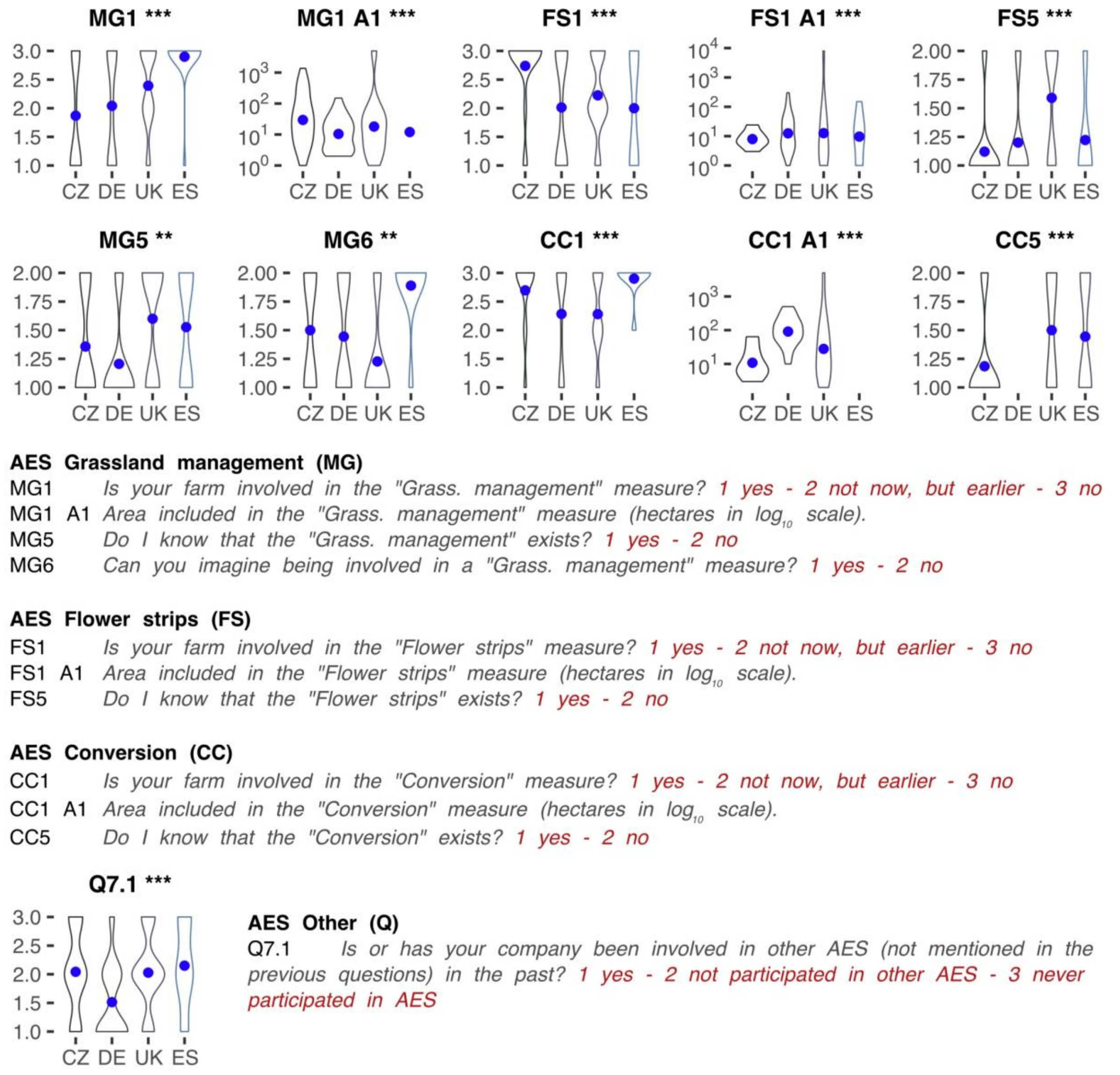

Figure 2.6: Adoption of AES by farmers. Violin plots show statistically significant differences (*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$) in the responses obtained from farmers between the four case studies (CZ, DE, UK, ES). No information was obtained for the variables CC_1_TEXT and CC5 for CS ES and DE.

Regarding AES, we found a statistically significant difference for 11 of the 15 variables analysed. In terms of past, German farmers have the most experience in implementing AES (score of 1.5). The Czech Republic has the highest score of ‘grassland management’ (1.9), followed by Germany and the United Kingdom (2.0 and 2.4). In contrast, Spain has the lowest implementation rate (score of 2.9), which may be related to the generally low proportion of grassland, which is consistent with the answers to question MG6 (score of 1.9). Interestingly, the United Kingdom also has the highest willingness to implement this measure (score of 1.2), although this does not reflect the actual situation (as shown by the answers to MG1). The absolute area (in hectares) of ‘grassland management’ (MG1 A1) loosely follows the trends shown in the previous question. The Czech Republic and Germany also have a much higher awareness of the existence of this scheme (scores of 1.2 and 1.4), compared to the UK and Spain, where the average scores are around 1.6 and 1.5 respectively. In contrast to the

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previous AES, the Czech Republic has only little experience with the adoption of the 'Flower strips' scheme (score of 2.7), which puts it in contrast with other countries that are more favourable to it (score of ~2.2). Unlike other countries (score of ~1.1), farmers in the United Kingdom have the least awareness of this AES (score of 1.6). Of all the AES considered, 'Conversion' is the least implemented in all CS, with the Czech Republic and Spain having almost no experience (scores of 2.7 and 2.9). Similarly, all CS have the least awareness of this AES compared to the previous two.

3. Farming system archetypes

3.1. Approach

In order to meet the assumptions required to upscale our FSA classification from CS to EU level (see deliverable D2.2 “BESTMAP Conceptual Framework Design & Architecture" for details) and after discussing possible attributes included in IACS/LPIS and FADN data, BESTMAP made the decision to keep the FSA classification simple, and build it on two primary dimensions, following the FADN approach of (1) farm specialisation and (2) economic size. Therefore, we used these two dimensions and a top-down approach with user defined thresholds for each of the dimensions to identify and map the FSAs for individual farms in each of the CS areas.

As data sources, we used national and regional datasets, generated directly from 'IACS/LPIS' (Integrated Administration and Control System / Land Parcel Identification System) or equivalent sources, rather than FADN itself. All CS data were stored and managed via the Preliminary Case Study Base Layer (MS3 and D3.1) and were handled according to GDPR rules and local data sharing agreements.

For the farm specialisation dimension, we chose to base our classification on the farm classification 'Type of Farming' (TF8) of FADN, as defined in Annex IV of EU regulation 2015/220. As planned in D1.3, we reduced the eight TF8 to four broad types of specialisation: general cropping ('P1'), horticulture ('P2'), permanent crops ('P3') and grazing livestock ('P4'). To map spatial LPIS data to these classes, we used the area-based rules defined in EU regulation 2015/220, stating that farms classified as P1, P2, P3 or P4 have to dedicate at least 2/3rds (66.6%) of the total farm area to the corresponding land use type. If this area condition was not met, the farm was classified as a fifth type of farm specialisation: 'mixed'.

For the economic size dimension, we adopted a simplified version of the FADN ES6 classification, which defines economic size categorically according to a series of 6 bounded economic ranges for total economic size (€). In addition to this a lowest category was recorded for farms with an (annual) economic size below €2000 – the minimum threshold for the main categories. For our classification system, 4 categorical values were assigned, as a simplification from the seven categories present under ES6: '<2000EUR', 'small', 'medium' or 'large'. Each of the 'small', 'medium' and 'large' categories were optimised such that within the sets available under the ES6 classifications across all BESTMAP case study regions, the criteria for each of 'small', 'medium' and 'large' farms was set so the totals in each category aligned as closely as possible to 1/3rd of the total sample (number of farms) each.

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Accordingly, the mapping of individual farms to a specific FSA was the result of a direct combination of the two dimensions explained above, as identified per farm. This procedure evidently produced a maximum possible number of 20 unique FSA classes in a given case study. For details on the methods and results of FSA definition and mapping, please see Deliverable 3.5 - ‘Farming System Archetypes for each CS’.

3.2. UK Case Study

In the Humber case study, the majority of farms focus on general cropping (P1), followed by farms focusing on grazing and livestock (P4) and farms combining both farm specialisations (mixed). In terms of the area of farmland, the pattern is even more pronounced in favour of P1 farms, which cover almost 90% of the total farmland area. While the number of farms specialising in permanent crops (P3) is relatively negligible, there are no farms with specialisation in horticulture (P2).

All categories of economic sizes are common across different farm specialisations. However, the majority of grazing and livestock farms (P4) are small or even <2000 EUR (still covering most of the farm area from all P4 farms). The majority of general cropping farms (P1) and mixed farms belong to the large economic size category.

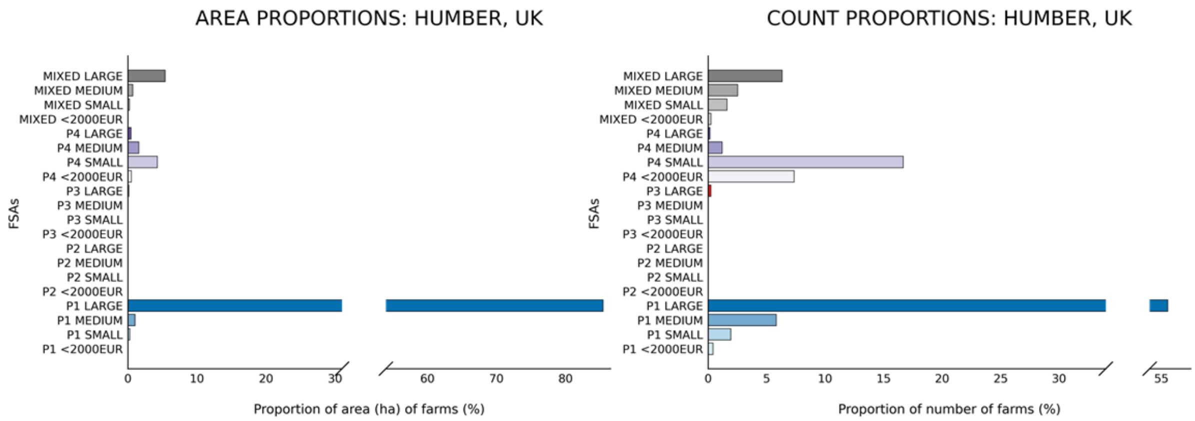

Figure 3.1: Fraction of farms for each FSA category in the Humber case study (UK) as a proportion of the area or total number of farms per case study region

In terms of spatial distribution, large P1 farms are commonly occurring in all parts of the Humber case study. However, in the northern part of the area, the farming landscape is more characterised by a mix of livestock, dairy production, and arable cropping. Here, dairy farming is relatively more dominant, with smaller farms and fields enclosed by hedgerows. In the southern part of the case study area, the farmland is dominated by intensive production of arable crops, especially cereals. Arable fields are larger, more open and only occasionally interspersed with pastures on heavier clay soils and very scarce semi-natural habitat.

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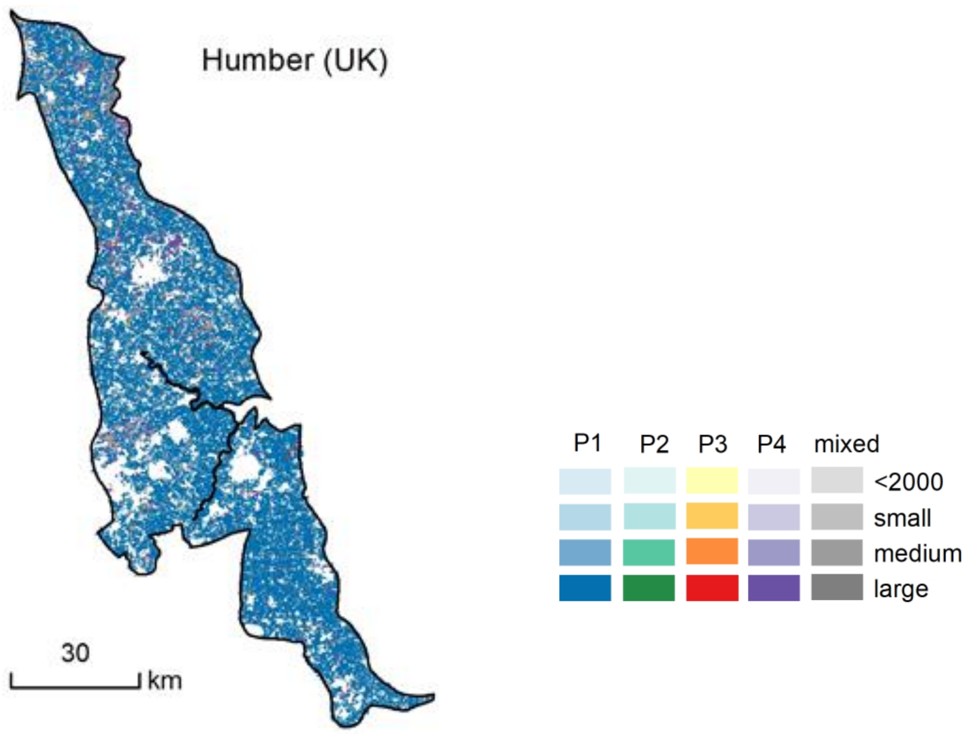

Figure 3.2: Spatial distribution of farming system archetypes in the case study area

3.3. DE Case Study

In the Mulde case study, most farms belong to the specialised grassland type (P4). While these farms are typically small in terms of their economic size, specialised arable farms (P1) as well as mixed farms mainly have a large economic size. Horticulture (P2) and permanent crops (P3) farms are not common in the case study area. In terms of area coverage, however, large farms on arable land (P1) cover the largest area from all identified farm systems (approx. 55% of the region's farmland), followed by large mixed farms (approx. 30% of farmland). The remaining 15% of farmland is dedicated to grazing livestock and forage crops (P4 farms).

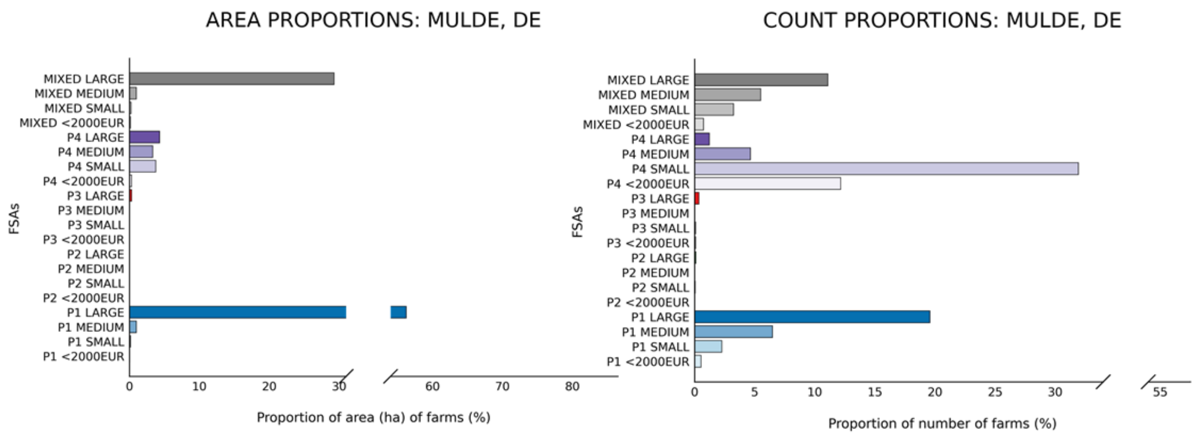

Figure 3.3: Fraction of farms for each FSA category in the Mulde case study (DE) as a proportion of the area or total number of farms per case study region

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Considering the distribution of FSAs in space, the large arable farms (P1) are predominant in the northern and central part of the case study. In the highland regions of the Ore mountains (southern part of the case study region), specialised grassland farms (P4) of different economic sizes are found, while the intermediate region is characterised by mixed farms that have both arable land as well as permanent grassland.

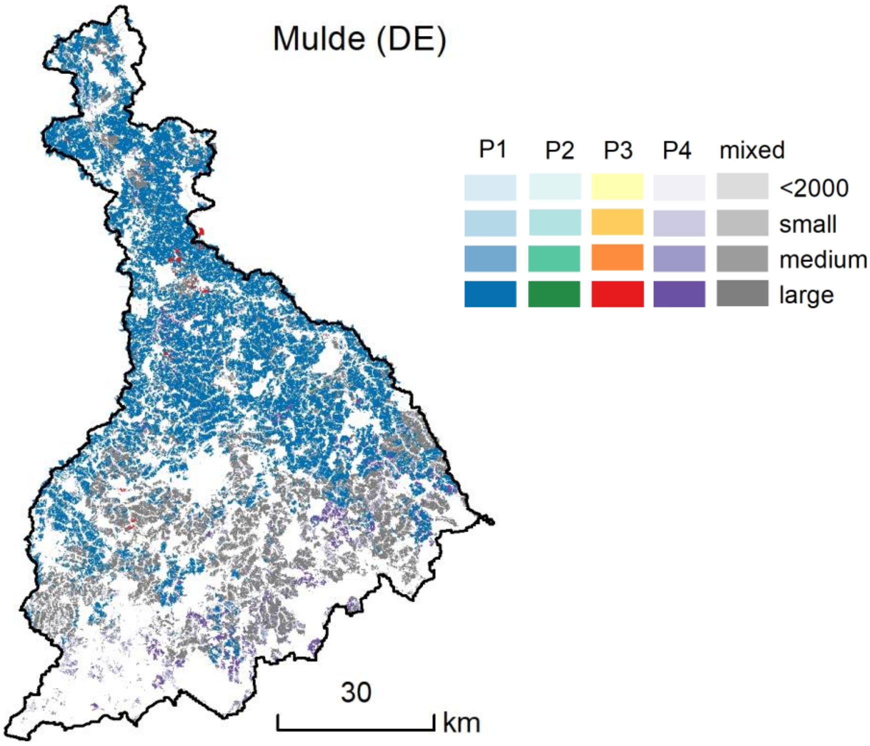

Figure 3.4: Spatial distribution of farming system archetypes in the case study area

3.4. CZ Case Study

In the South Moravian case study, the majority of farms belong to one of the two farm specialisation categories: general cropping (P1; 28%) or permanent crops (P3; 32%). While P1 farms are typically large in terms of economic size (but many also very small, <2000€), P3 farms are more evenly distributed between small, medium and large economic size categories. Large P1 farms occur across the entire lowland part of the case study region and cover by far the largest area from all identified farm systems (78% of the region's farmland). While similar in the number of farms, P3 farms cover a much smaller area (only 3%) and are scattered across the lowland part of the region, in locations where climatic and soil conditions are favourable for maintaining vineyards and fruit plantations.

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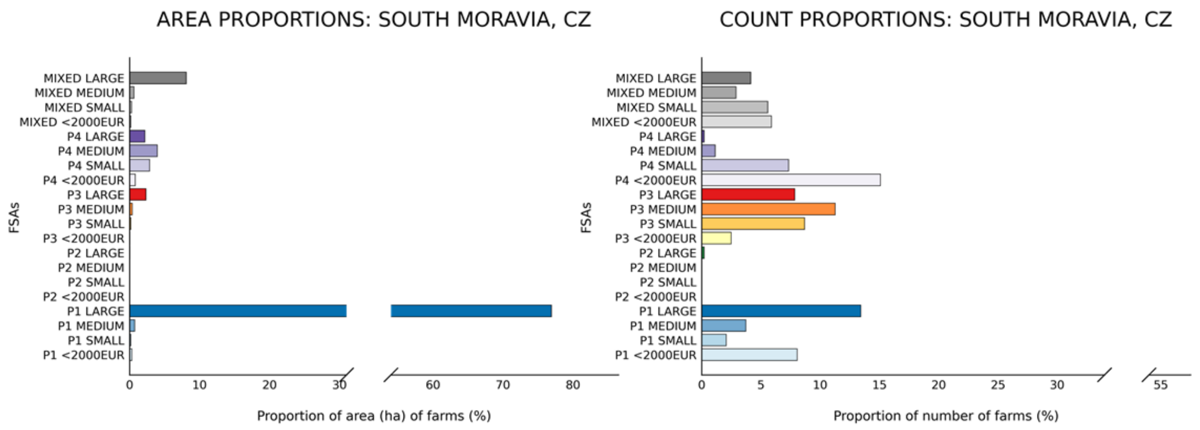

Figure 3.5: Fraction of farms for each FSA category in the South Moravia case study (CZ) as a proportion of the area or total number of farms per case study region

Only three farms are specialising in horticulture (P2) but a considerable number of farms (23%) are dedicated to grazing livestock and forage crops (P4). These are located predominantly in the eastern hilly part of the region, covering 10% of the region's farmland, where conditions are favourable for maintaining pastures and permanent grasslands. P4 farms are typically much smaller in economic size than P1 or P3 farms, most of them being in the small or <2000 category. Finally, mixed farms (16% of all farms) that combine general cropping with grazing livestock are located at the interface between P4 farms in the highlands and P1 farms in the lowlands. Mixed farms range in economic size but large mixed farms are the second most extensive farming system in the region (8% of the region's farmland).

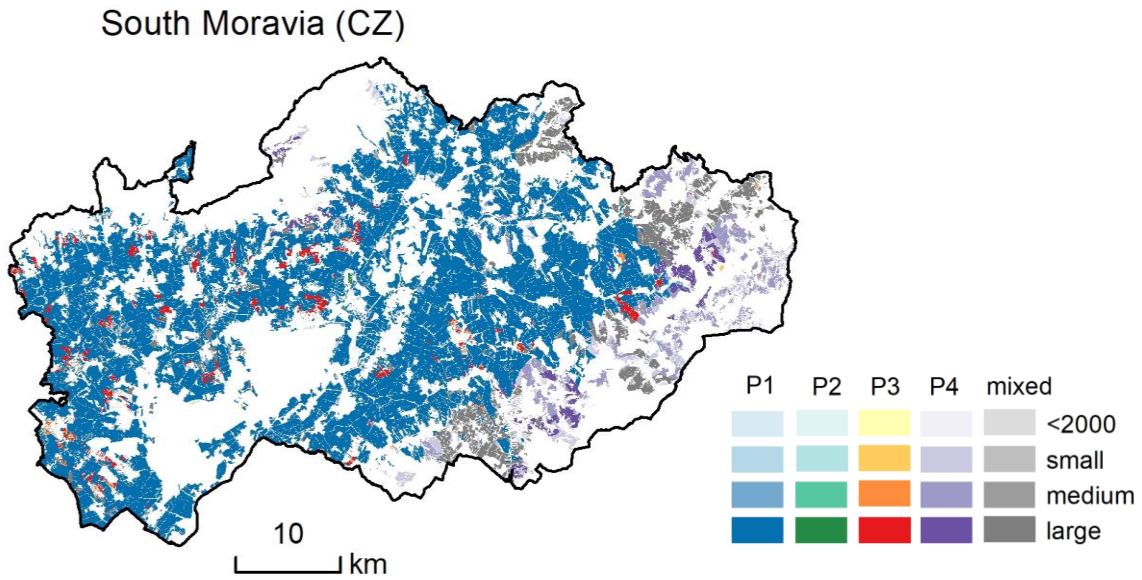

Figure 3.6: Spatial distribution of farming system archetypes in the case study area

3.5. ES Case Study

The areas dedicated to pastures and forage crops for animals are located in the Pyrenean and pre-Pyrenean areas of Catalonia in the northern part of the CS. This is due to the abundant bovine livestock that exists in these areas, where lower temperatures favour the presence of cattle such as the Friesian breed (or pint of milk cow), whose characteristics do not allow it to adapt to very hot areas. These regions correspond to the large and middle categories of P4 farms. These two FSA categories have large area coverage but relatively small proportion in terms of the number of farms.

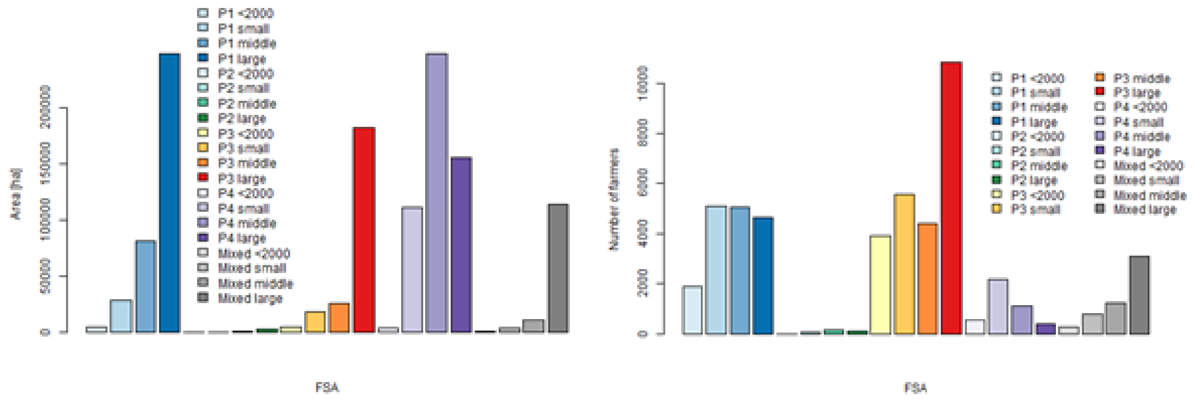

Figure 3.7: Fraction of farms for each FSA category in the Catalonia case study (ES) as a proportion of the area or total number of farms per case study region

Agricultural areas categorised as P1 (general cropping) occur in the middle of the CS region. This part of Catalonia corresponds to a flat area, ideal for growing cereals such as wheat. The flat topography of this place allows this type of temporary plantation to develop adequately. P1 farms are relatively evenly split among different economic size classes, but naturally, large P1 farms manage the majority of the farmland dedicated to general cropping on arable land.

A third of the agricultural sector of Catalonia is the southwest area. It is managed predominantly by P3 farms focusing on permanent cultivation. These areas are characterised by the presence of vineyards (mostly in coastal areas) and other types of plantation such as orchards, as the climate of these areas allow their adequate development. P3 farms are spread among all classes of economic size, with the large ones being the most common and covering the majority of the farmland area.

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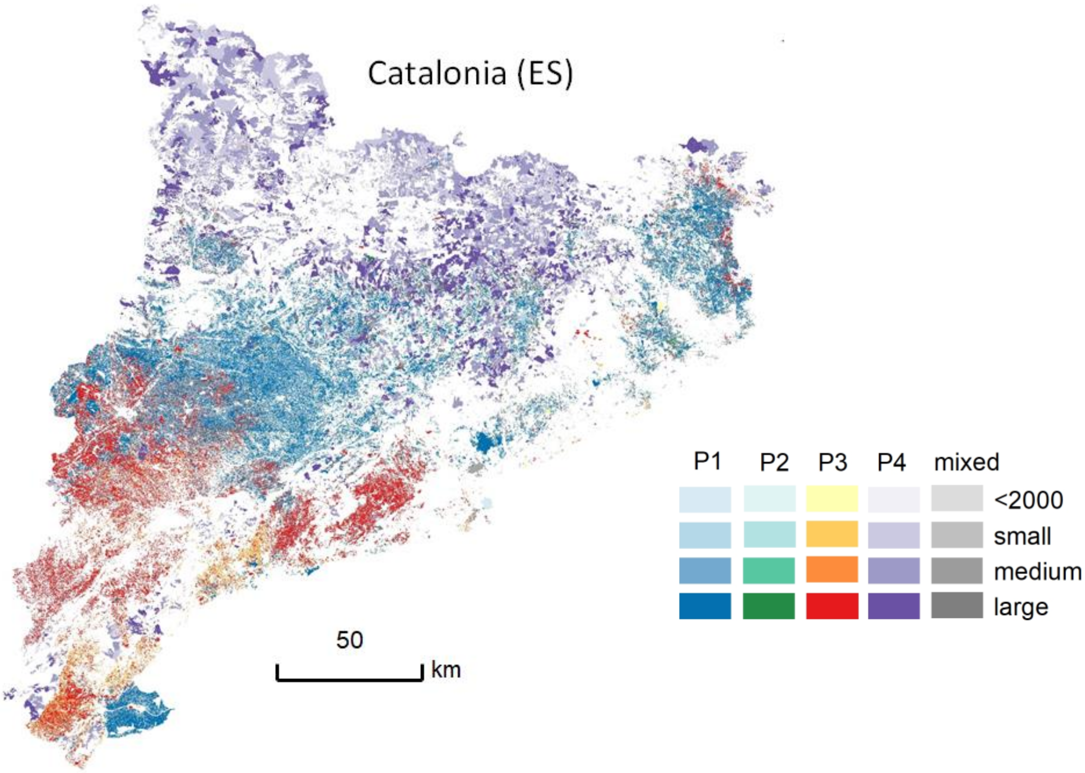

Figure 3.8: Spatial distribution of farming system archetypes in the case study area

3.6. RS Case Study

Agricultural areas categorised as P1 (general cropping) are by far the most dominant FSA in the Bačka region. Due to flat topography and high soil quality, the region is ideal for growing cereals such as wheat and maize. While in terms of the farm count, P1 farms are equally distributed among all four economic size categories, in terms of the area coverage, large P1 farms take up the absolute majority of the farmland.

Horticulture and permanent crops (P2 and P3) are also quite significant in the CS. Areas of vegetable production are scattered over smaller or bigger areas across Bačka. Wine growing production is present in Subotica-Horgos sandy terrain.

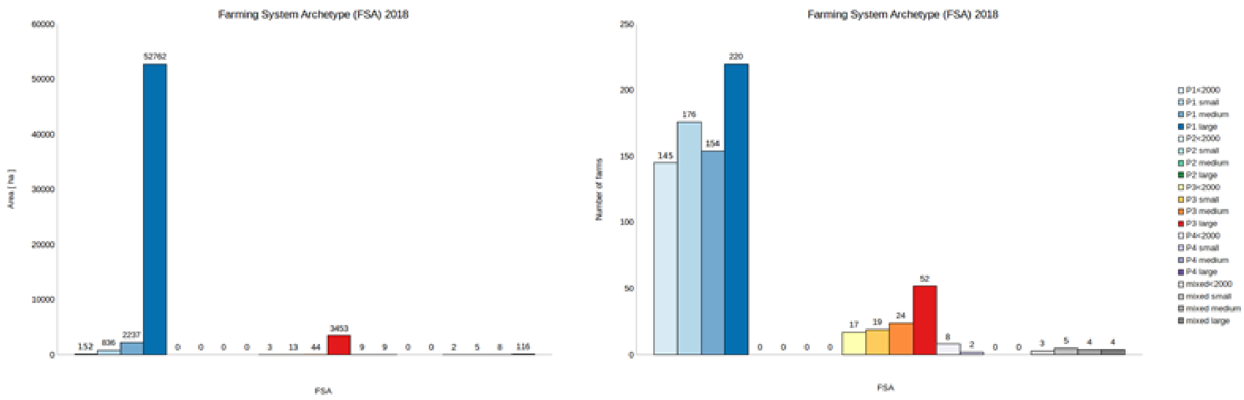

Figure 3.9: Fraction of farms for each FSA category in the Backa case study (RS) as a proportion of the area or total number of farms per case study region

Pastures with grazing livestock and forage crops (P4) are less represented in the CS. Their coverage has decreased over time, mainly in favour of arable land, so that today there are only small fragmented areas of pasture. Most of them are in the municipalities of Kanjiža and Žabalj on state property. Local communities of cattle owners have the right of use, and it is possible to obtain financial support for the maintenance. Pastures are more represented than meadows, and mostly cattle and sheep graze, rarely goats. There is no exact data on the total number of cattle grazing, but the number is considerably smaller (up to 1,5 per ha) than in livestock farming. Meadows are areas grown with natural grasses that are mowed for the purpose of storing fodder, which is used during the dormant period of vegetation. Mowing is practised mainly where grazing is not suitable, and is done by machine or by hand, usually once in the period of grass cutting.

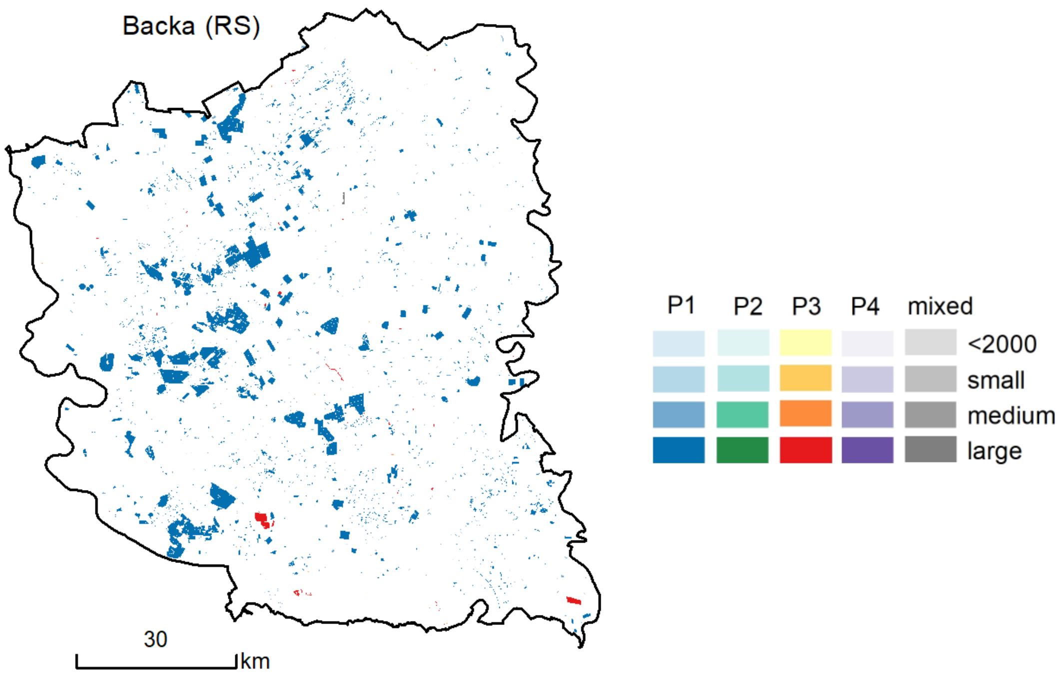

Figure 3.10: Spatial distribution of farming system archetypes in the case study area

3.7. Similarities and Differences

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In four out of five case study regions, ‘P1 large’ FSAs dominate the proportions of both total farm counts (DE=20%, CZ=13%, UK=56%, RS=24%) and total farm areas (DE=56%, CZ=77%, UK=85%, RS=93%). In Catalonia (ES), the FSA categories are more evenly represented, with the exception of P2 (horticulture) farms that are the least common types of farms in ES but also in all other CS.

When total area of farms is considered as the unit of analysis, the proportions of FSA allocations belonging to the ‘large’ FSA classification categories increases, demonstrating the concentration of farm area dedicated to ‘large’ farms. This is especially the case as there is no upper limit on farm economic size in the highest ES6 class (>= 500 000 EUR). For example, the increase in ‘large’ FSA classifications as a proportion of the total sample upon this change to farm area units is +57.8 percentage points for DE (32.4% to 90.1%), +63.7 percentage points for CZ (25.8% to 89.6%), and +29.1 percentage points for the UK (62.3% to 91.4%).

In all case studies, the proportion of both counts and areas of total farms belonging to the P2 ‘horticulture’ farm specialisation is negligible. The P3 'permanent crops’ specialisation is not really present in Mulde (DE) or Humber (UK) but hosts a decent population of total farms and total farm areas in South Moravia (CZ) and Backa (RS), while it is the most common farm specialisation in Catalonia (ES). Across most case study regions, the ‘mixed’ farm specialisation hosts a sizable proportion of total farm counts (e.g. DE=20.6%, CZ=18.5%, UK=10.7%) and total farm areas (e.g. DE=30.6%, CZ=9.1%, UK=6.3%), with the exception of Backa (RS), where the fraction of mixed farms (both in counts and area coverage) is negligible.

3.7.1. Adoption of agri-environmental practices across FSAs

We examined and mapped the relationships between FSAs and the adoption of agri-environmental practices (AEPs, used here as an umbrella term for simplified groups of agri-environmental schemes, ecological focus areas and organic farming investigated in detail in BESTMAP) per case study. By this approach, we (1) illustrate the credibility of FSAs as a set of farming contexts in which distinct profiles of environmental policy uptake decisions are made and (2) test whether the general philosophy of the FSA typology - devising farmers into groups with similar structural characteristics - can be a good criterion for targeting and developing more tailored agri-environment policies in Europe. This was done for three BESTMAP case studies (DE, CZ, UK) for which detailed data on agri-environmental measures were available and could be consistently grouped into the main AEP groups considered within BESTMAP activities.

The FSA typology was able to generate sets of distinct profiles of decisions in relation to the adoption of AEPs (Figure 3.11). Although the bar plots are arranged so that farming systems next to each other are most alike, there is rarely a complete synergy in the profile of AEPs adopted. This is apparent in the distributions of P1 and P4 farm specialisations in the Humber (UK) case study, especially as these relate to the clear aggregate distinctions present for the AEPs on grassland maintenance, fallow, vegetation buffers and conversion to forest.

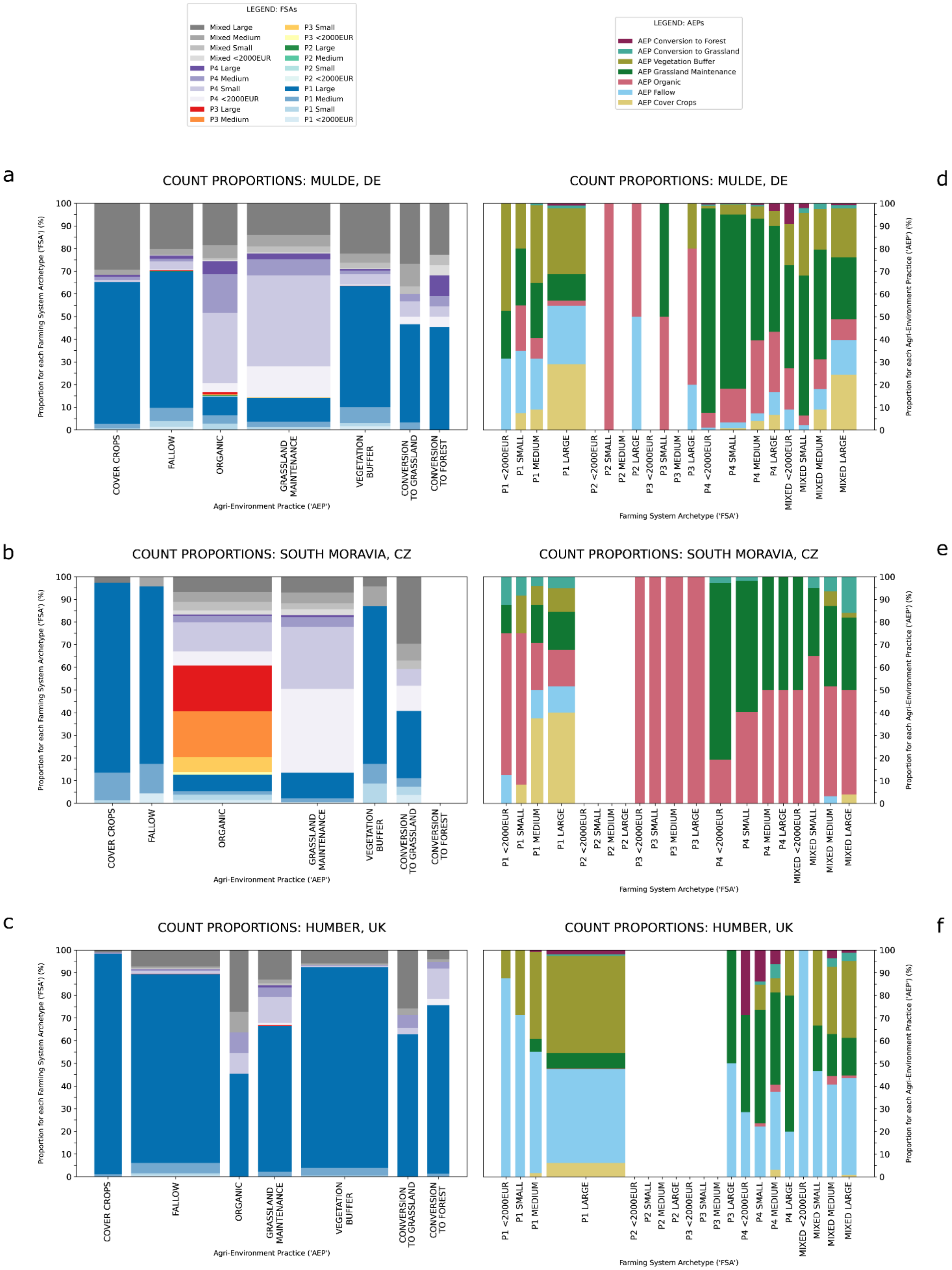

Figure 3.11: The relationship between FSAs and AEPs per case study region. The bar width is proportional to % of total number of farms (per case study), such that maximum total bar width is up to 10x the fixed minimum width. The total sample is calculated by the total sum of all farm counts adopting each AEP category, so a farm could 'count twice' or more in the 'total sample' if it adopts multiple AEPs. However, there are distinct patterns in AEP adoption that are similar in all CS. Across the three considered CS, the AEPs cover crops, fallow land and vegetation buffers are being adopted

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by P1 and mixed farms but predominantly in the 'large' economic size category (Figure 3.11a, b, c). On the other hand AEPs focusing on organic farming or grassland maintenance occur across a wider range of farm specialisations (including also P3 and P4 farms) but are not dominated by large farms. Rather they are more common in medium and small farms, and in the case of South Moravia (CZ), also by the P4 farms (i.e. < 2000 EUR; Figure 3.11b). This CS is also specific in terms of organic farming, which can be found in all types of FSAs, including P3 farms, a diversity not found at the same magnitude in the other CS.

This capacity to capture distinct sets of AEP adoption profiles is reflected coherently also per individual policy in the differential sets of FSA compositions present for each AEP (Figure 3.11d, e, f). A clear pattern can be distinguished here, showing that larger farms have the tendency to adopt a wider portfolio of AEPs, while smaller farms are more likely to adopt only a few types of AEPs. P3 farms are an exception in the AEP adoption, as they tend to adopt only a small number of AEPs across all economic sizes (case of DE) or focus exclusively on organic farming as an AEP (case of CZ).

The FSA typology is also capable of producing profiles of farming systems which do not adopt AEPs (Figure 3.12). Here, the FSA classification can be useful for making cross-CS comparisons which examine particular populations of farming systems that are not inclined to adopt AEPs at present. The main pattern common for all CS is driven by the economic size of farms: predominantly small and >2000 EUR farms are more likely to not engage in any AEPs than large and medium sized farms.
However, certain patterns in the FSA/AEP relationship are specific to a particular CS. For example, whilst South Moravia (CZ) appears to have the most diversity in the FSAs for which non-adoption is a substantial issue, this pattern is reversed in comparison to Mulde (DE) and Humber (UK) once the area of farming systems is taken into account as South Moravia (CZ), in fact, has the largest single proportion of non-adoption concentrated in farms of a single FSA ('P1 large', 55%). This is caused largely due to the vast farmland area on which large P1 farms operate (large P1 farms consist 14% of all farms but cover almost 80% of farmland area).

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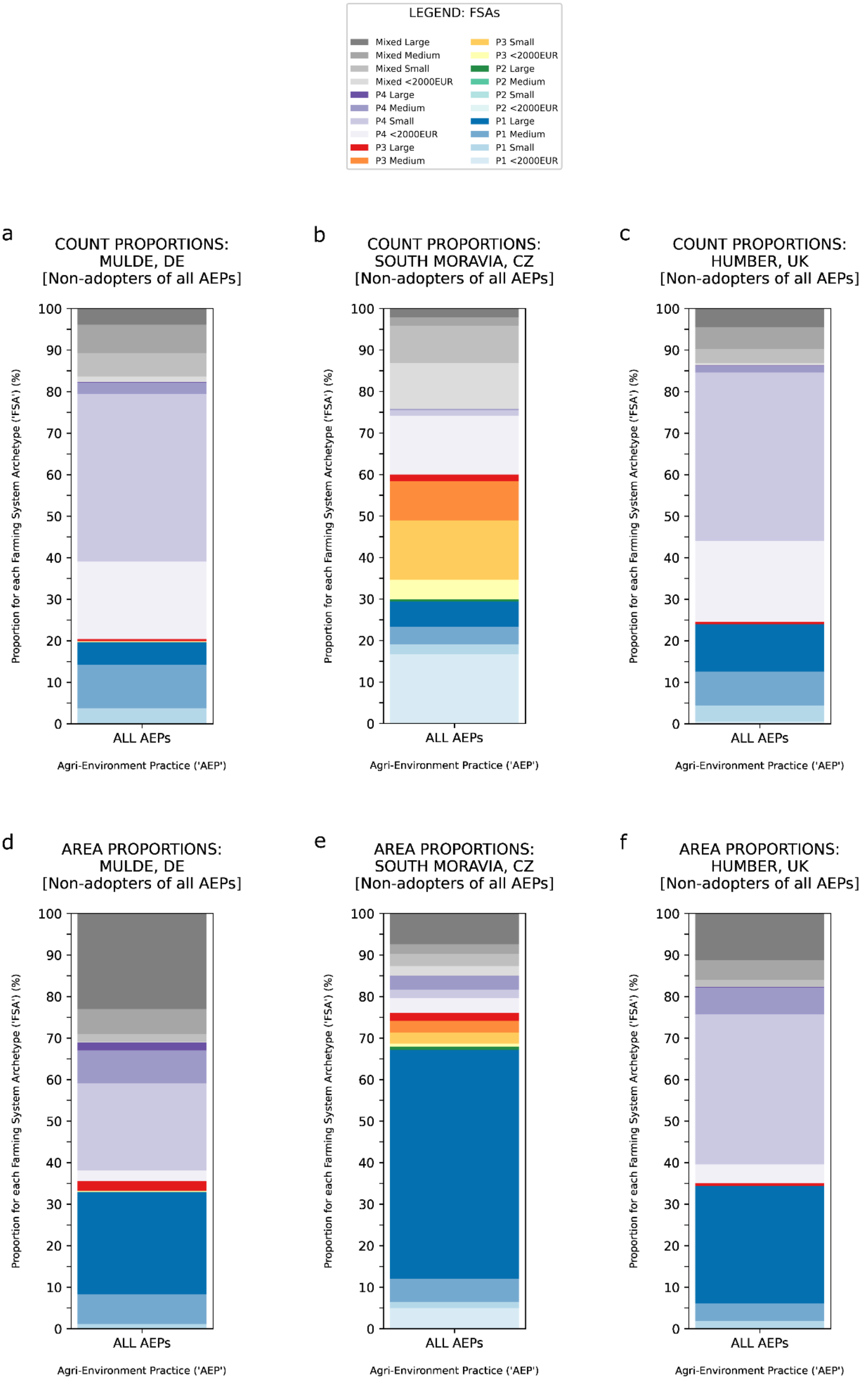

Figure 3.12: Farm count (a-c) and area (d-f) compositions for FSAs which did not adopt any AEP.

4. Biophysical modelling

4.1. Approach

In all case studies, we modelled the impact of selected AEP on biodiversity, food and fodder, carbon sequestration and water quality. We selected AEP that are widely adopted in all or most of the CSs and grouped them in order to facilitate inter-CS comparisons. The modelled measures are: buffer areas/strips, cover crops, land-use conversion to permanent grassland, land-use conversion to forest, maintaining permanent grassland, organic farming and fallow land. Each model was run under two scenarios: **(1)** a scenario of current land use (i.e. using the available IACS data from 2016/2019) and **(2)** a scenario without AEP.

For the biodiversity model, we used ensemble species distribution models (SDMs) of farmland birds using land-use and management data as explanatory variables. The models were then projected onto scenario conditions to obtain habitat suitability maps for each bird species. Finally, a biodiversity index was constructed based on relative species richness, ranging from 0 (none of the modelled species is present) to 1 (all modelled species present).

The food and fodder model was based on standard output coefficients (StOCs) of agricultural crops and agricultural yield data from the Europe-wide WOFOST model. We then used existing empirical data to estimate the relative effect of AEP on crop yield. The results were then combined in order to produce case study maps of standard output, in €/ha, under both scenarios.

Carbon sequestration was modelled using a regression approach based on LUCAS observation points and climate and soil characteristics as explanatory variables. The modelled soil organic carbon values, in t/ha, were then modified depending on the type of crop cultivated and AEP applied on every parcel.

For the water quality model, we applied the InVEST nutrient delivery ratio (NDR) model, which uses a mass balance approach of the movement of nutrients through space derived from empirical relationships. Input data to the model included land cover and crop maps and fertiliser rates. The outputs consist of surface nitrogen (N) and phosphorus (P) export values in kg/ha/year.

More information on the models including detailed factsheets with description of input data, approach and outputs can be found in Deliverable 3.3 - “Ecosystem service, biodiversity and socio-economic models for each case study”.

4.2. UK Case Study

P1 farms are the predominant ones in the Humber watershed. The biodiversity model output shows large variations in relative species richness across farms of the same FSA type, and minor increases in median values in the current AEP scenario compared to the no AEP one (Figure 4.1). As expected, standard output is highest in large P1 farms. P1 and mixed farms are also the ones with the highest nutrient export in water. Decreases in standard output due to AEP adoption are detectable for P3 and P4 farms, whereas nutrient export is reduced across all FSAs in the current AEP scenario. Soil organic carbon content is similar across FSAs, with slightly higher values in large mixed and large P4 farms. Changes in soil organic carbon content are small between the two scenarios.

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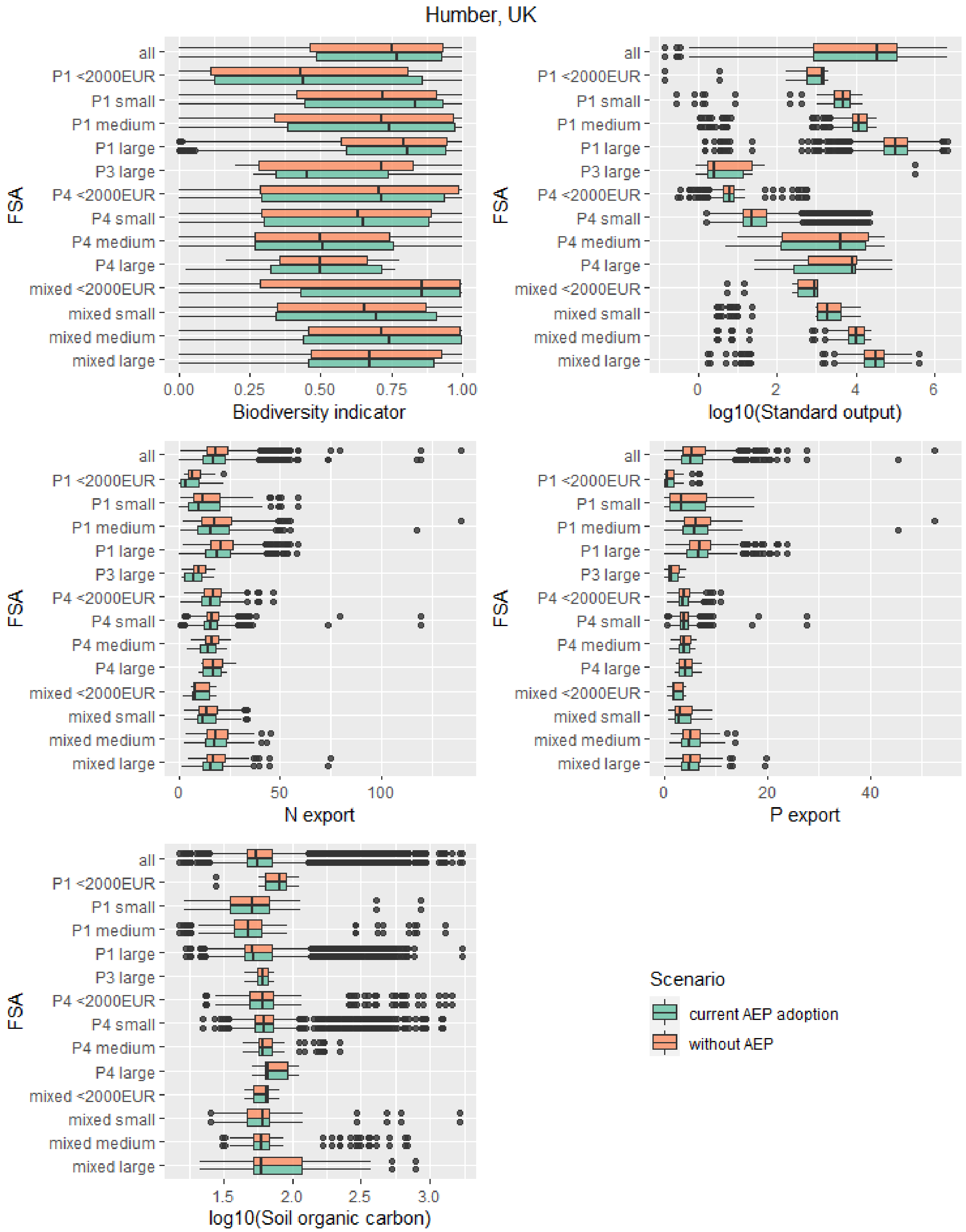

Figure 4.1: Farm-level values of the modelled biodiversity indicator and ecosystem services for the two AEP adoption scenarios, for all farms and for each FSA type in the Humber, UK. For visualisation purposes, one outlier point (i.e. with N export > 400 kg/ha and P export > 100 kg/ha) was removed from the plot.

4.3. DE Case Study

In the Mulde River Basin, the biodiversity indicator shows little changes between the two AEP-adoption scenarios (Figure 4.2), except for P3 medium farms, which experience a considerable increase in relative species richness when AEP are adopted. AEP adoption has minor negative impacts on standard output, whereas larger reductions in nitrogen and phosphorus export can be seen between the two scenarios. Soil organic carbon increases only slightly under the current AEP scenario.

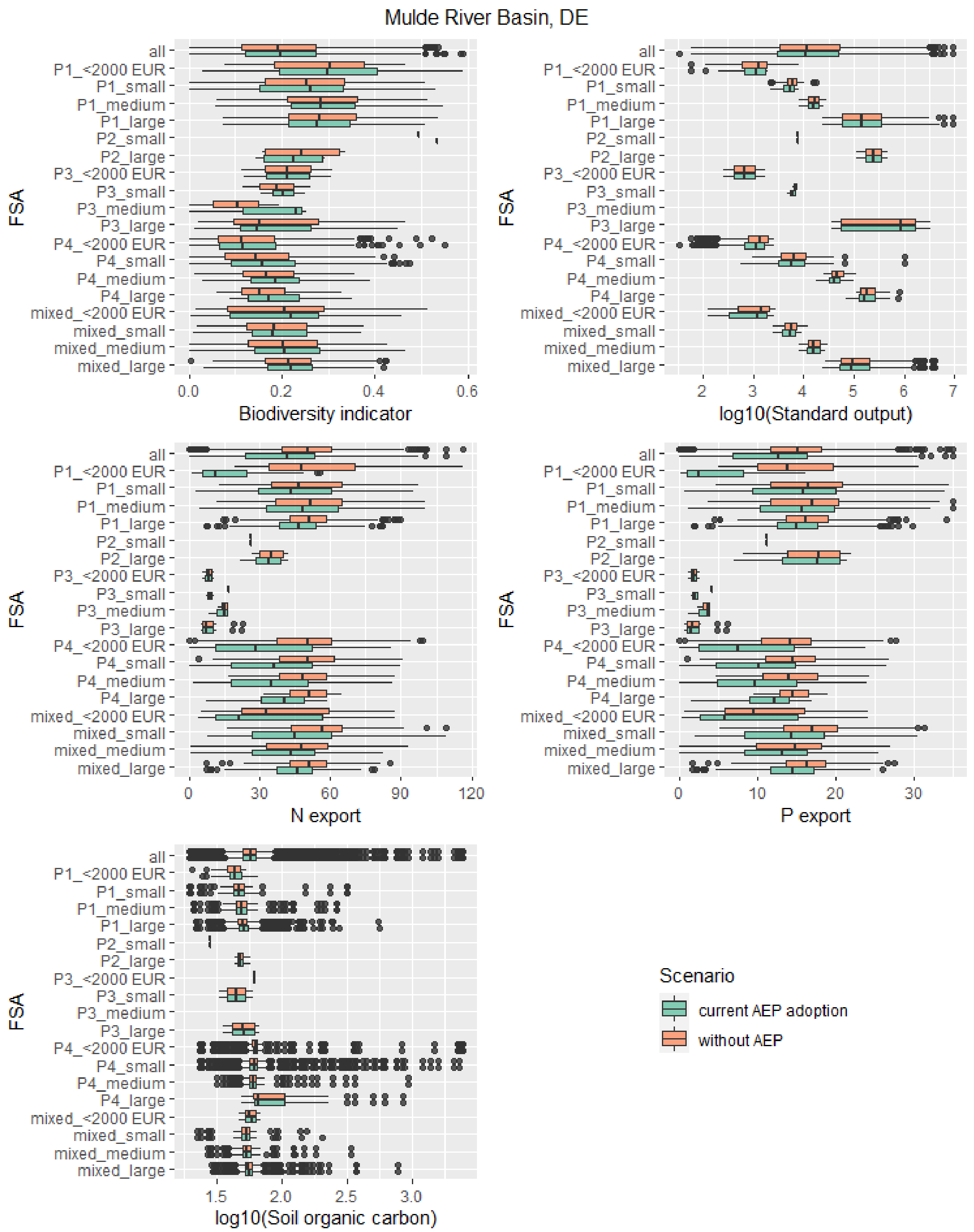

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Figure 4.2: Farm-level values of the modelled biodiversity indicator and ecosystem services for the two AEP adoption scenarios, for all farms and for each FSA type in the Mulde River Basin, DE.

4.4. CZ Case Study

In South Moravia, the biodiversity indicator responds quite strongly to the effect of AEPs, with a cross-scenario change that is more pronounced than in the other CSs (Figure 4.3). Standard output is lower in the AEP scenario across most FSA types, and nitrogen and phosphorus export is also lower when AEP are applied, with more important changes for P4 and mixed farms. Soil organic carbon is positively affected by the AEP.

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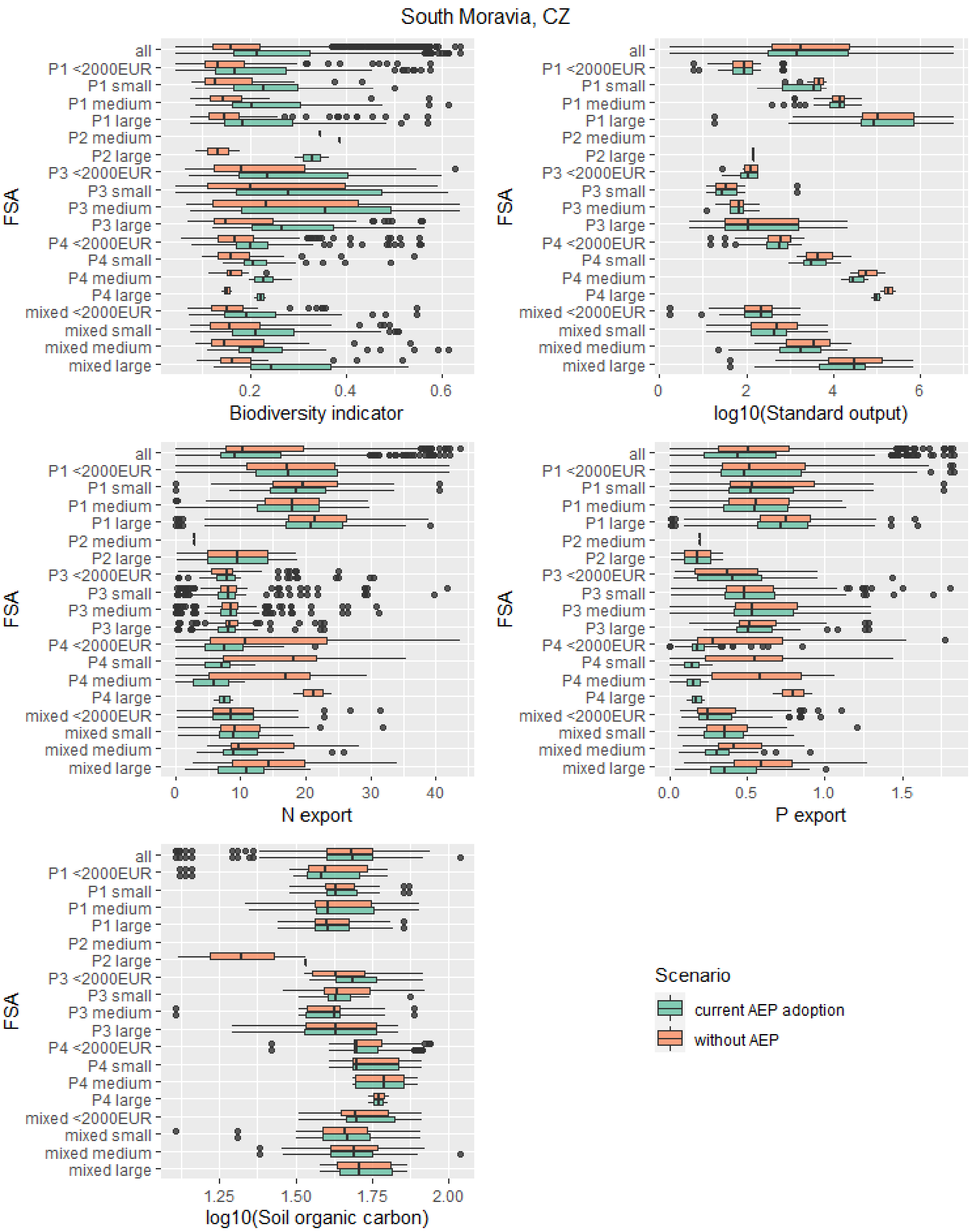

Figure 4.3: Farm-level values of the modelled biodiversity indicator and ecosystem services for the two AEP adoption scenarios, for all farms and for each FSA type in South Moravia, CZ.

4.5. ES Case Study

The positive effect of AEP for biodiversity is equally spread across different FSAs in Catalonia (figure 4.4), where the positive change is small but consistent. Changes in standard output are very minor between the two scenarios, while nutrient export in water decreases, though by a small fraction, in the scenario with AEP. Positive changes in soil organic carbon content are also detectable in the AEP scenario compared to the one without AEP.

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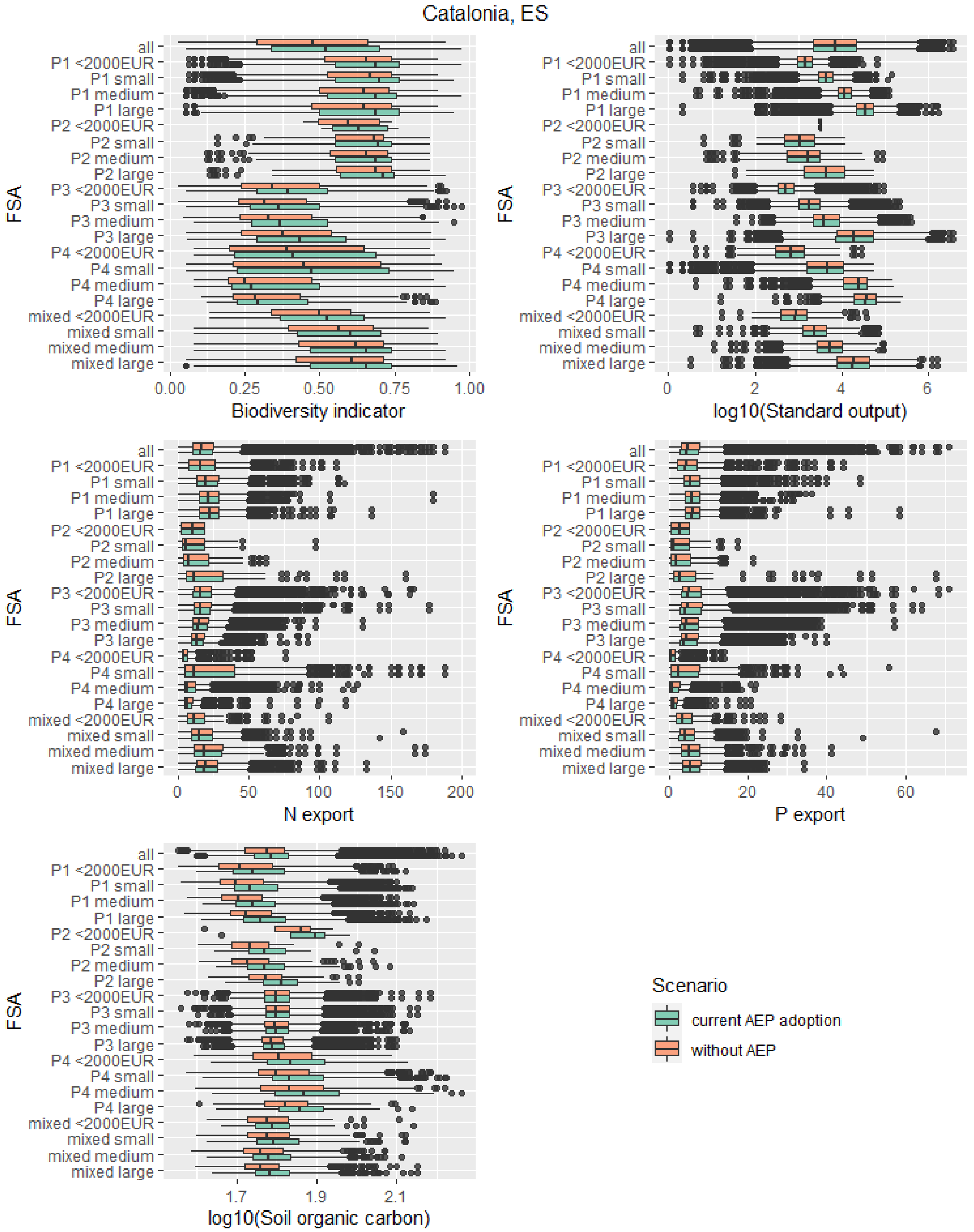

Figure 4.4: Farm-level values of the modelled biodiversity indicator and ecosystem services for the two AEP adoption scenarios, for all farms and for each FSA type in Catalonia, ES. For visualisation purposes, two outlier points (one with N export > 200 kg/ha and one with P export > 90 kg/ha) were removed from the plots.

4.6. RS Case Study

The Serbian case study (Bačka region) differs from other case studies in that AEP are not implemented. Another specificity is the lack of the LPIS database. Information on farms comes from the National Platform for Digital Agriculture - AgroSens. AgroSens encompasses mainly P1 type of farms and is also biased in the economic size dimension, with higher frequency of large farms. This needs to be taken into account when interpreting the result for the Bačka region.

Biodiversity indicators show significant differences in the current scenario that includes elements of non-agricultural vegetation (shrubs, trees, fallow land) that farmers kept on their land denoted as “surrogate schemes” and the scenario where they are removed. These vegetation elements across agricultural parcels have a positive effect on biodiversity.

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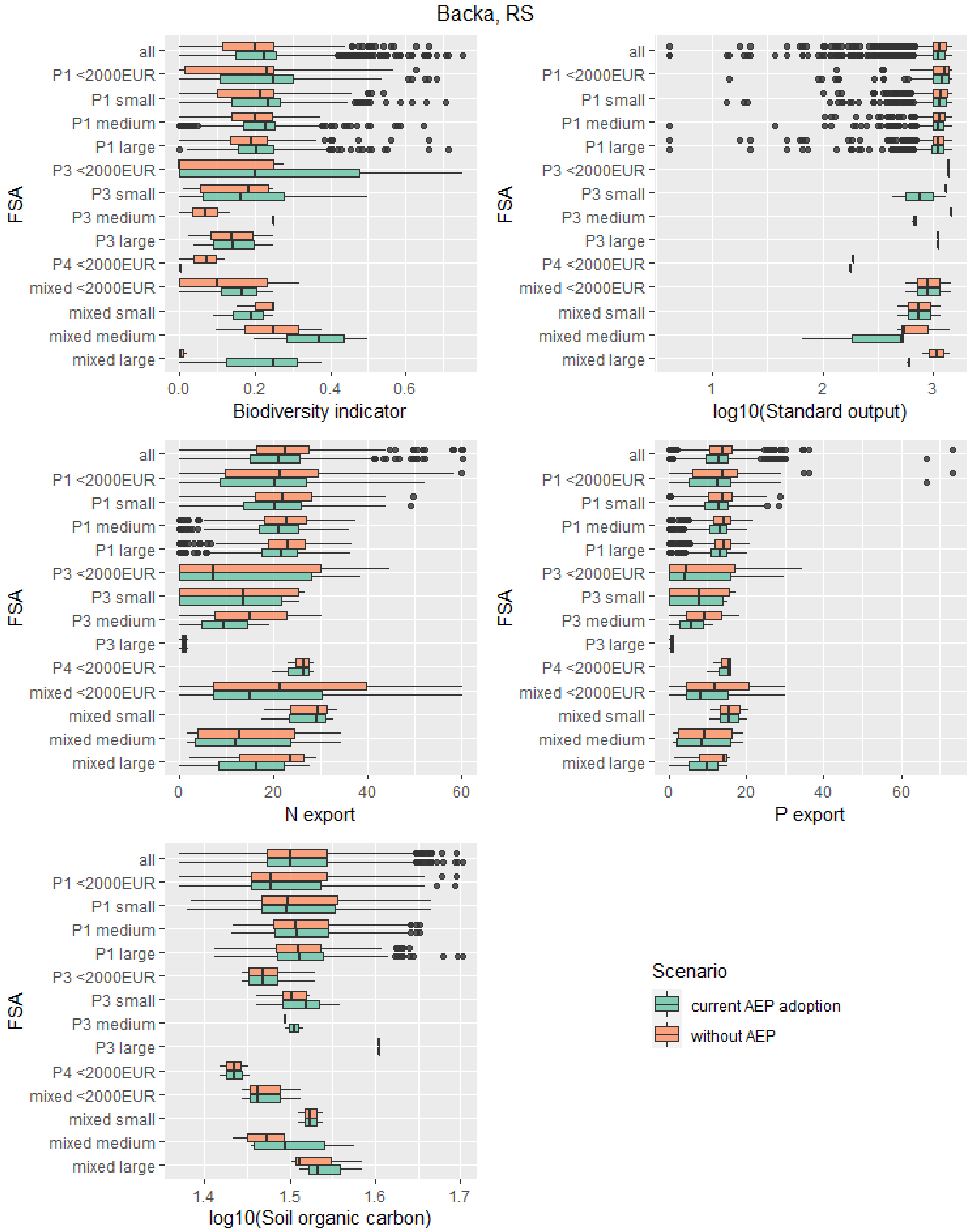

Figure 4.5: Farm-level values of the modelled biodiversity indicator and ecosystem services for the two AEP adoption scenarios, for all farms and for each FSA type in Backa, RS.

4.7. Similarities and Differences

Outputs of each model for both AEP adoption scenarios, extracted for all farms in each CS, are shown in figure 4.6. Across all CSs, the comparison between the two scenarios showed only marginal contributions of AEP, under the current adoption levels, to the enhancement of biodiversity and ecosystem service provision, as the change in biodiversity and ecosystem service provision between the two scenarios is not substantial. Nonetheless, we can observe statistically significant differences in the model results for the biodiversity indicator in four out of five CSs, for nitrogen and phosphorus export in all CSs, for soil organic carbon content in Catalonia, ES; and for the standard output in Backa, RS.

The biodiversity model was specifically designed to detect the effects of AEP on habitat suitability of farmland species, by comparing different AEP adoption scenarios (Roilo et al., 2022). Cross-CS comparisons of the biodiversity indicator values should instead be avoided, as the indicator is based on a different set (and a different number) of farmland species in each CS (see D3.3 - “Ecosystem service, biodiversity and socio-economic models for each case study” for the CS-specific species selection). For example, in RS the indicator is based on only 4 species, three farmland birds and one mammal, the European ground squirrel. In ES instead, 38 farmland bird species were modelled, so that the presence (or absence) of one species has a comparatively smaller impact on the final relative species richness indicator. In the UK, the model performance was satisfactory only for 7 relatively common species, while some rare species had to be excluded due to insufficient records, so that the indicator has high values compared to the other CSs.

N and P export levels are comparable across CSs, though the values are generally higher in DE for both nutrients. In CZ, P export is very low compared to the other CSs: this is likely caused by the fact that the levels of P_2O_5 fertilisers in Czechia have been in the last decade on average lower than in other European countries, such as in neighbouring Germany.

Soil organic carbon content is also comparable across CSs, except for the low values observed in RS, but other European-wide datasets (e.g. https://soilgrids.org/, May 2020 version) also indicate generally lower soil organic carbon contents in the Pannonian basin, compared to the other CSs.

The results of the standard output model show more variance across CSs, which is to be expected, as the model is based on country-specific standard output coefficients for different crop classes.

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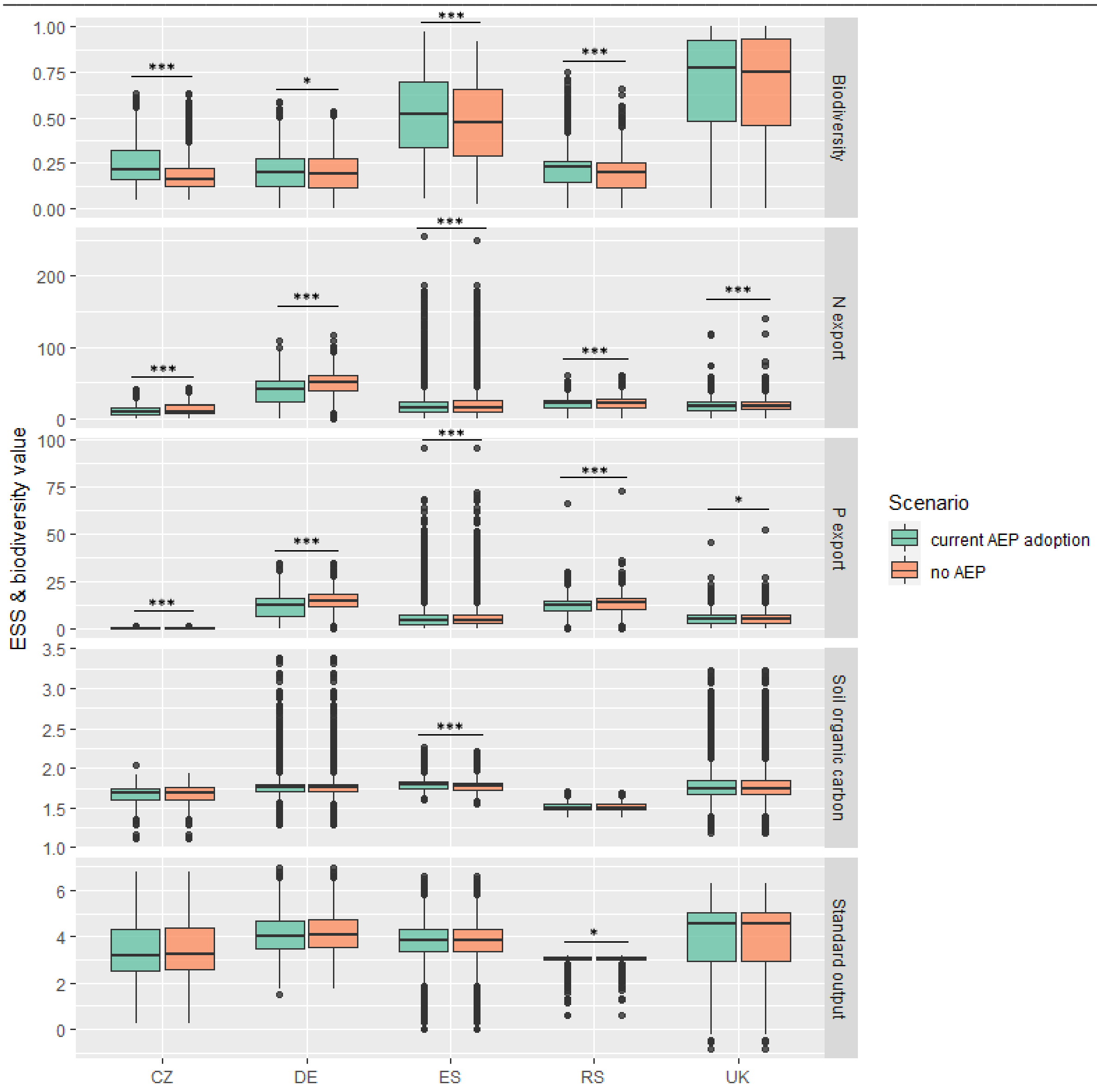

Figure 4.6: Farm-level values of the modelled biodiversity indicator and ecosystem services for the two AEP adoption scenarios in each CS. Values of soil organic carbon and standard output are log10-transformed. The Kolmogorov-Smirnov test was used to test for significant differences in the value distribution between the two scenarios (* indicates p-value lower than 0.05, *** p-value lower than 0.001). One outlier (i.e. with P export > 100 kg/ha) was removed from the plot to ease visualisation.

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5. Agent-based modelling

5.1. Approach

Agent-based models (ABMs) are process-based simulations that allow to represent decisions of individual farmers and their interactions with others as well as the environment (Schulze et al., 2017; Huber et al., 2018). In BESTMAP, the purpose of the ABM (BESTMAP-ABM) is to determine the adoption and spatial allocation of four selected groups of agri-environmental schemes (AES) by individual farmers in the five BESTMAP case studies. The selected types of AES are flower strips, cover crops, maintaining permanent grassland and conversion of arable land to permanent grassland. These four AES were chosen (i) as they existed, with roughly similar implementations, in most CSs, (ii) according to the relative importance in terms of spatial coverage of AES across CSs and (iii) were seen as relevant for future AES implementations of the European Common Agricultural Policy (e.g. conversion of arable land to permanent grassland).

With the model, the effect of different scenarios of policy design on patterns of adoption can be investigated. In particular, the following contract characteristics can be varied:

- Contract duration (1, 5 and 10 years) for each AES
- Fraction of farmers with access to advisory support
- Level of administrative effort for the farmer to implement and monitor each AES (low, medium and high)
- Compensation per hectare enrolled in the proposed contract per year for each AES

Based on these variations, the model can be used to study the social-ecological consequences of agricultural policies at different spatial and temporal scales. In combination with biophysical models, this allows us to test the ecological implications of different designs of the EU's Common Agricultural Policy.

The decision-making framework of the ABM is structured as a three-step procedure where choices are made at different spatial levels. We propose this hierarchical decision-making in the context of AES because our own interview campaign (see Deliverable D3.4 'Summaries of data, obstacles and challenges from interview campaigns') and other empirical studies (e.g. Lienhoop and Brouwer, 2015) have shown that some farmers are not at all open to consider a specific AES and therefore do not enter into in-depth deliberations. The different processes that are run in one time step include:

1. **Openness to specific AES:** Decision-making at farm level on whether at all the farmer is open to consider adoption of a specific AES
2. **Subset suitable fields:** Selection of fields that are available for AES adoption
3. **Deliberation and spatial selection**: Deliberation on which AES to adopt on which field based on expected and offered payment level

The main structure of the ABM is the same across CS. Due to differences in the availability of data for parameterizing and calibrating the model as well as different existing policies and regulations, some parts of the model are adapted to local peculiarities. Furthermore, specific requirements for the models for the UK due to Brexit and for Serbia as a non-EU member state are considered.

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For details on the methods and a description of each case study model in a structured form which follows the ODD+D protocol (Müller et al., 2013), please see Deliverable 4.1 - 'Agent-Based Models for each CS'.

The original idea was to parameterize the expected payment level with data from a discrete choice experiment which was part of the online survey (see section 2). Since the sample size of the survey was too small to obtain statistically significant results for the expected payment level of different farmer types, for those CS where AES already exist (i.e. all CS except Serbia), we developed a workaround approach to parameterize the expected payment level by deriving a mean expected payment level with which the current adoption rates can be reached (see Deliverable D4.1 for details and the data augmentation analyses that were performed instead for Serbia). We assume that the expected payment levels of all farmers of the same farmer type are normally distributed, i.e. the mean expected payment level is the mean of the normal distribution of expected payment levels. From the available data, we can derive the current adoption rates for a specific scheme and the offered payment level. For the standard deviation, assumptions have to be taken, e.g. based on results from other discrete choice experiments, or a sensitivity analysis has to be performed with which the effect of different standard deviations can be analysed.

The following subsections contain the outputs of the models for the different case studies. In addition to the replication of the status quo, i.e. the current adoption rates of the selected AES, we have simulated four scenarios that differ in contract duration, payment, advisory support and administrative effort. For the status quo scenario, we assume a contract duration of five years, payment levels as currently offered, medium bureaucratic effort and advisory support levels as indicated in the online survey (for ES and UK no advisory was considered in the baseline scenario). The other selected scenarios are characterised as follows:

- **Advisory support:** All farmers have access to advisory support. Farmers with access to advisory support are assumed to accept a 5% lower payment level for all AES.
- **High payment:** The offered payment for all schemes are increased by 10% compared to what is currently offered.
- **Short contracts:** The contract duration is reduced to one year. Farmers are assumed to accept 10% lower yearly payments for 1 year contracts compared to what is currently offered per year for a five year contract duration.
- **Low bureaucracy:** The administrative effort associated with the scheme (e.g. reporting, monitoring) is reduced. Farmers are assumed to accept 5% lower payments for low administrative effort.

Assumptions for the changes in expected payment level are loosely based on results from empirical studies. The studies that serve as references are summarised in Table 5.1.

Table 5.1: Summary of empirical results that give a reference for the change in expected payment level under different policy scenarios.

Scenario	Change in expected payment level	Source
Access to advisory support	-5%	Hasler et al. 2019, Espinosa-Goded et al. 2010

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Contract duration	-10% (1 year contract) +40% (10 years contract)	Hasler et al. 2019, Latacz-Lohmann & Breustedt 2019, Christensen et al. 2011, Ruto & Garrod 2009, Santos et al. 2015
Administrative effort	-5% (low bureaucracy) +5% (high bureaucracy)	Ruto & Garrod 2009

For all scenarios, the mean adoption rates at farm level of the selected schemes aggregated over 50 repeated model runs are shown. Adoption rates are also presented separately by farm specialisation as defined in the Farming System Archetypes (FSA). Further subdivision by economic size to capture the full range of farmer types defined in the project is possible in principle. However, this leads to small group sizes for some case studies, which makes it difficult to calibrate the model to reflect the status quo for all farmer types.

5.2. UK Case Study

Figure 5.1 shows the comparison of farm adoption rates in our designed scenarios. According to the adoption data, the adoption rates of cover crops and arable land conversion to grassland are very low, at 0.28% and 0.17% respectively. Unfortunately our model cannot simulate these extremely low adoptions. The results show that all the tested policy designs can help improve farmers' adoptions significantly. Increasing the offered payment by 10% and reducing the contract length to 1 year work the best compared to the other two alternative policies.

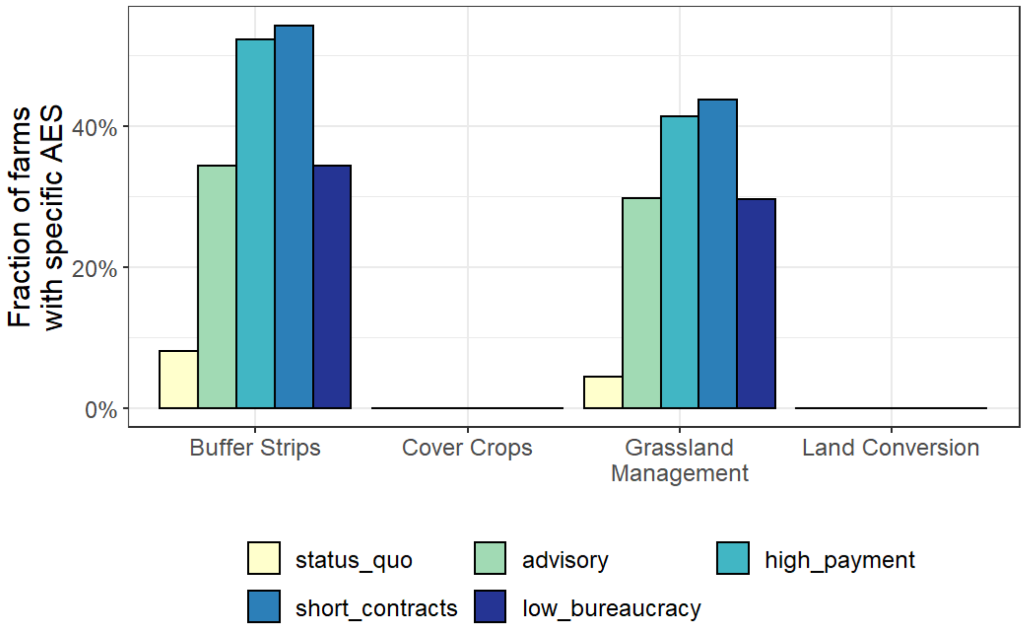

Figure 5.1. Adoption rates of the selected AES at farm level in the UK case study for different policy scenarios

Figure 5.2 shows the breakdown of FSA farms' adoption in the UK. P1 farms have higher adoption rates of the four AES in comparison to other types of farms. To visualise the adoption rates better, subplots of P4 and P5 farms are plotted on a smaller y scale. As P2 farms do not exist in the Humber region, the subplot of P2 farms displays adoption rates of 0. P3 farms do not take up any AES in the scenarios we run. This is in line with the adoption pattern of P3 farms, in which P3 farms' adoption rates of the four AES are 0.03% of the grassland management AES adoption and no adoptions of the other three AES.

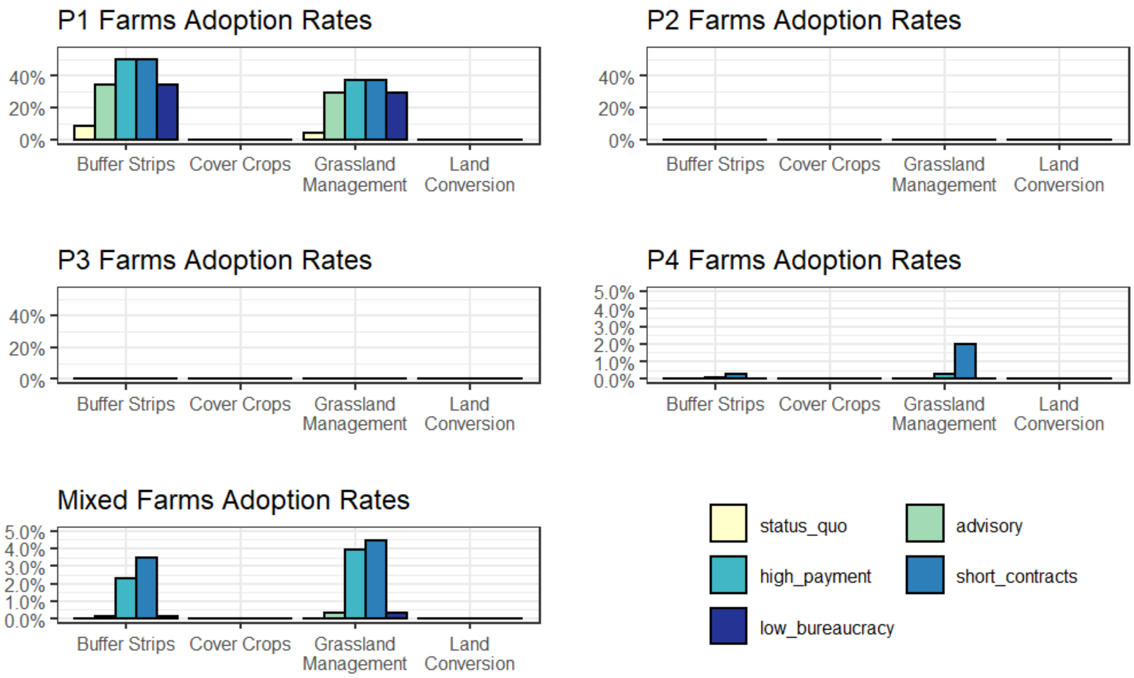

Figure 5.2. Adoption rates of the selected AES at farm level in the UK case study for different policy scenarios separated by farm specialisation (FSA)

5.3. DE Case Study

In the German CS, three of the four selected AES are currently offered. Conversion of arable land to permanent grassland is included in the model as a hypothetical scheme designed to test the impact of potential policy changes. Since values to calibrate the model are missing, the scheme is, however, not covered in the model analyses presented here.

Figure 5.3 shows the fraction of farms that adopt the selected AES for different policy scenarios. The simulated adoption rates of the status quo agree almost perfectly with those reported in the LPIS data with deviations of only 1.6% at maximum (not shown). All of the presented policy scenarios lead to an increase in adoption rates compared to the simulated status quo. Across the selected AES the trends are similar with higher effects the higher the current adoption rate. The largest increase in adoption can be observed when shortening the duration of contracts from five years to one year. Similar increases in adoption rates can be achieved by increasing compensation by 10%. It is assumed that decreasing the administrative effort has a smaller impact on the payment level that farmers accept compared to the effect through a decrease in contract duration. Consequently, the increase in adoption rate for low administrative effort is smaller than for short contracts. The most interesting observation is the change in adoption rate when all farmers have access to advisory support (versus 59% in the status quo). In this case, the change in openness to participate in AES must also be considered. Based on the results of the online survey (section 2), openness to cover crops is substantially higher for farmers with advisory support than for farmers without such support (70% vs. 56%). For buffer strips, openness is however only slightly higher (54% vs. 53%) and for grassland, even fewer farmers with advisory (50%) are open than without (62%). The effect of lower accepted payment levels with advisory support is therefore partly compensated by fewer farmers being open. Therefore, we observe only marginal increases in adoption rates when increasing the access to advisory support.

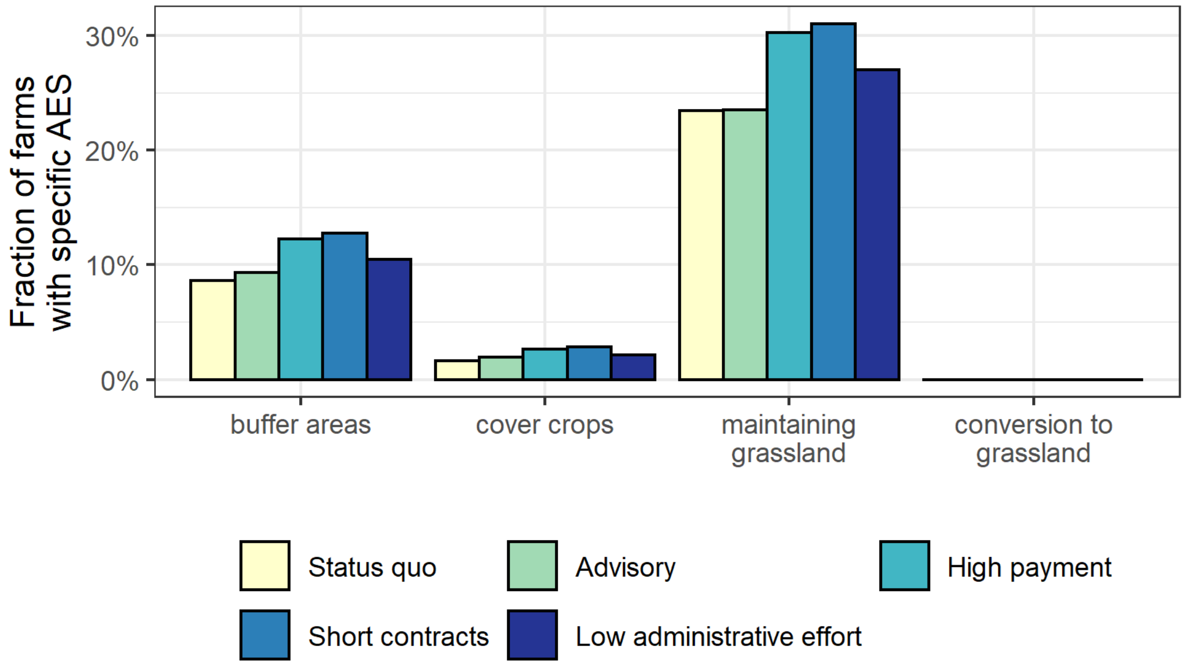

Figure 5.3. Adoption rates of the selected AES at farm level in the DE case study for different policy scenarios

Figure 5.4 shows the results separated by farm specialisation (as part of the FSA classification). For the German case study ABM, only P1, P4 and mixed farmers are considered since P2 and P3 farmers with mostly horticulture and permanent crops do not have (much) suitable land available to apply AES. Furthermore, only a small number of farmers fall into this category in the DE case study (c.f. section 3.3).

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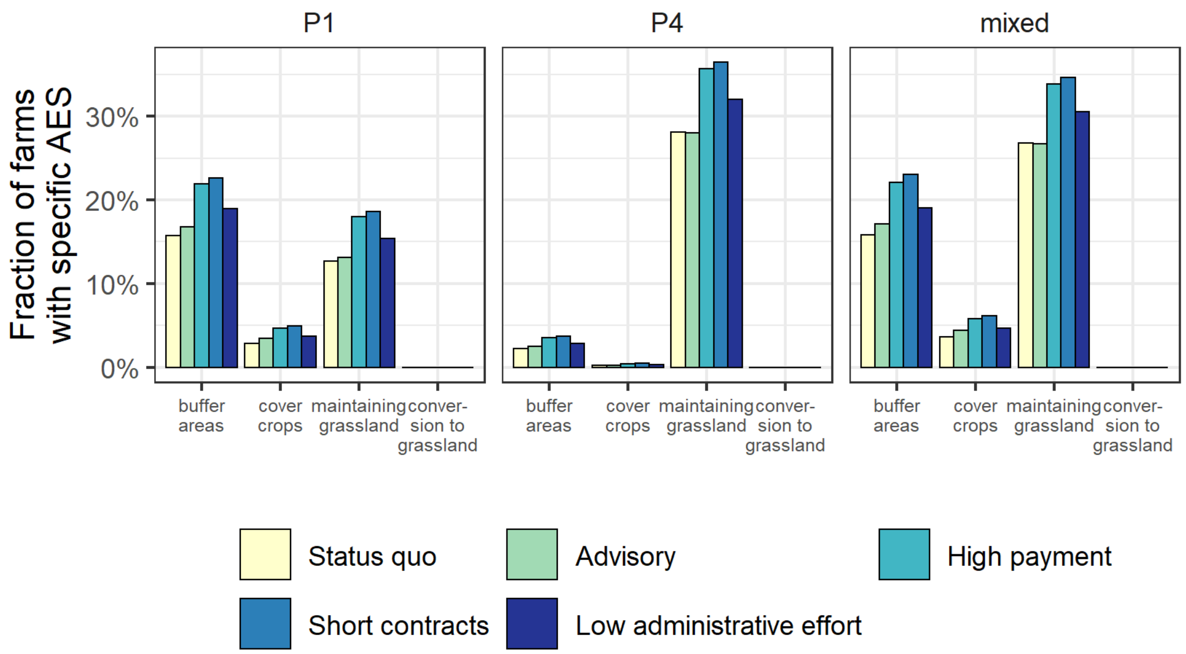

Figure 5.4. Adoption rates of the selected AES at farm level in the CZ case study for different policy scenarios separated by farm specialisation (FSA)

5.4. CZ Case Study

In the Czech CS, three of the four selected AES are currently offered. Cover crops are currently offered as Ecological Focus Areas but not as AES. Therefore, the scheme is included in the model as a hypothetical scheme designed to test the impact of potential policy changes but since values to calibrate the model are missing, the scheme is not covered in the model analyses presented here.

Figure 5.5 shows the fraction of farms that adopt the selected AES for different policy scenarios. The adoption rates reported in the LPIS data can be mapped by simulating the status quo with an accuracy of up to 4% (not shown). All of the presented policy scenarios lead to an increase in adoption rates compared to the simulated status quo. The largest increase in adoption can be observed when shortening the duration of contracts from five years to one year, followed by increasing the compensation by 10%. The effect of an increase in access to advisory support (100% vs. 35% in the status quo) is similar to that of decreasing the bureaucratic effort. For both scenarios it is assumed that farmers accept a 5% lower compensation. As shown in the online survey, Czech farmers are also more open to participating in AES if they receive advisory support. Only for buffer strips, farmers without access to support are slightly more open (62% vs. 63% of farmers are open to buffer strips).

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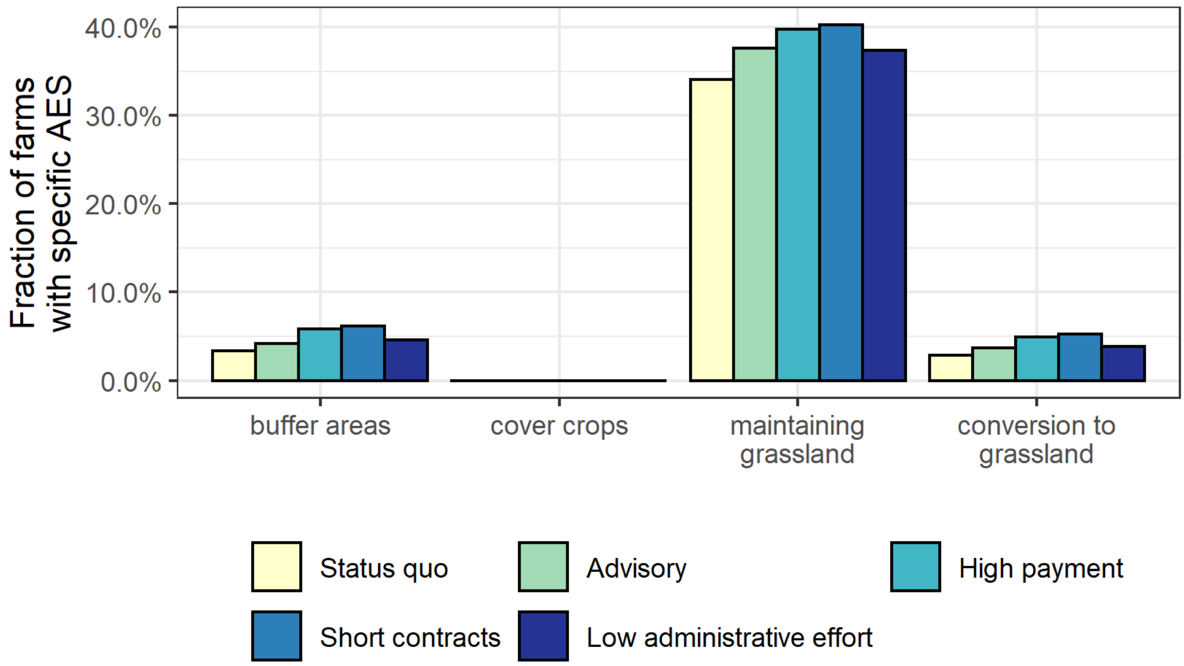

Figure 5.5. Adoption rates of the selected AES at farm level in the CZ case study for different policy scenarios

Figure 5.6 shows the results separated by farm specialisation (as part of the FSA classification). For the Czech case study ABM, only P1, P4 and mixed farmers are considered since P2 and P3 farmers with mostly horticulture and permanent crops do not have (much) suitable land available to apply AES. Although a rather large share of farmers falls into the P3 category, these farmers own only a small fraction of the total area (c.f. section 3.4).

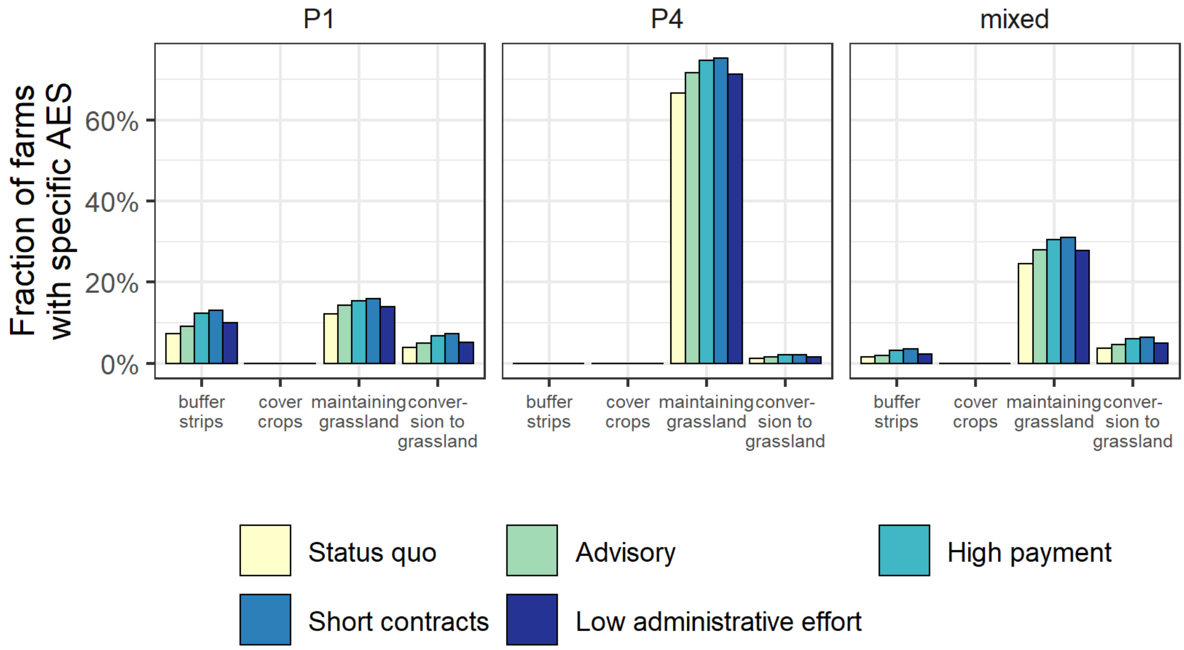

Figure 5.6. Adoption rates of the selected AES at farm level in the CZ case study for different policy scenarios separated by farm specialisation (FSA)

5.5. ES Case Study

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Figure 5.7 shows the comparison of farm adoption rates in our designed scenarios in ES. The results show that all the tested policy designs can help improve farmers' adoptions. However, the increasement of adoptions with grassland management is much lower, compared to the adoptions of other AES with the tested policy designs. In general, shorter contracts and higher payment work better in improving farmers' adoption rates than offering free advice and reducing bureaucracy burden.

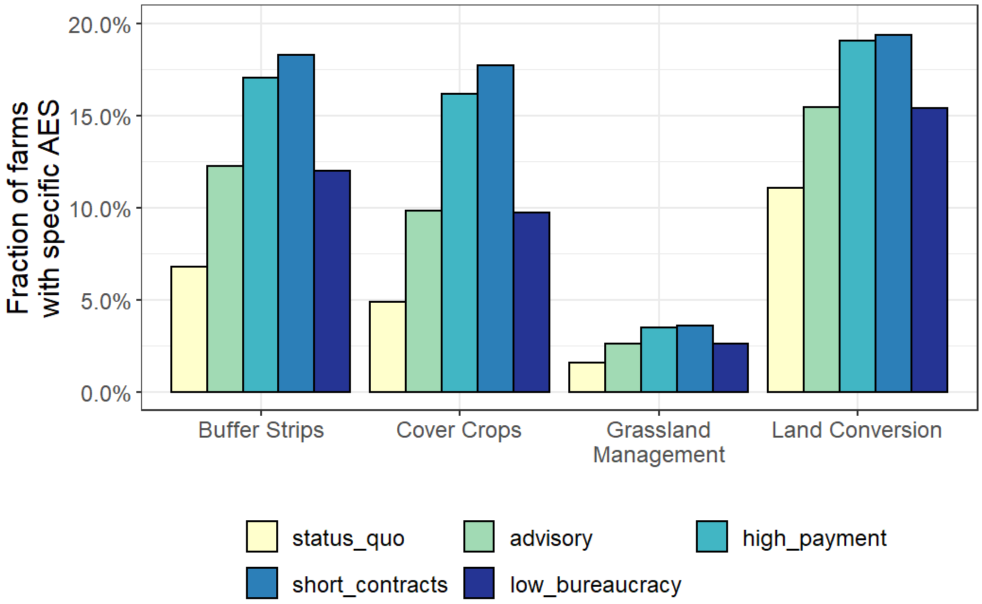

Figure 5.7. Adoption rates of the selected AES at farm level in the ES case study for different policy scenarios

As currently buffer strips and arable land conversion to grassland are not offered in ES, the baseline values of the two AES, including offered payment levels and adoption rates, are the averages of the baseline values in other case studies where these two schemes exist. The results of the two schemes are hypothetical.

Figure 5.8 shows the breakdown of FSA farms' adoption in ES. The results show that P2 farms do not take up the four AES, which is in line with the real-world situation according to the available adoption data. Other FSA farms' adoptions are improved under the four alternative policy designs we tested.

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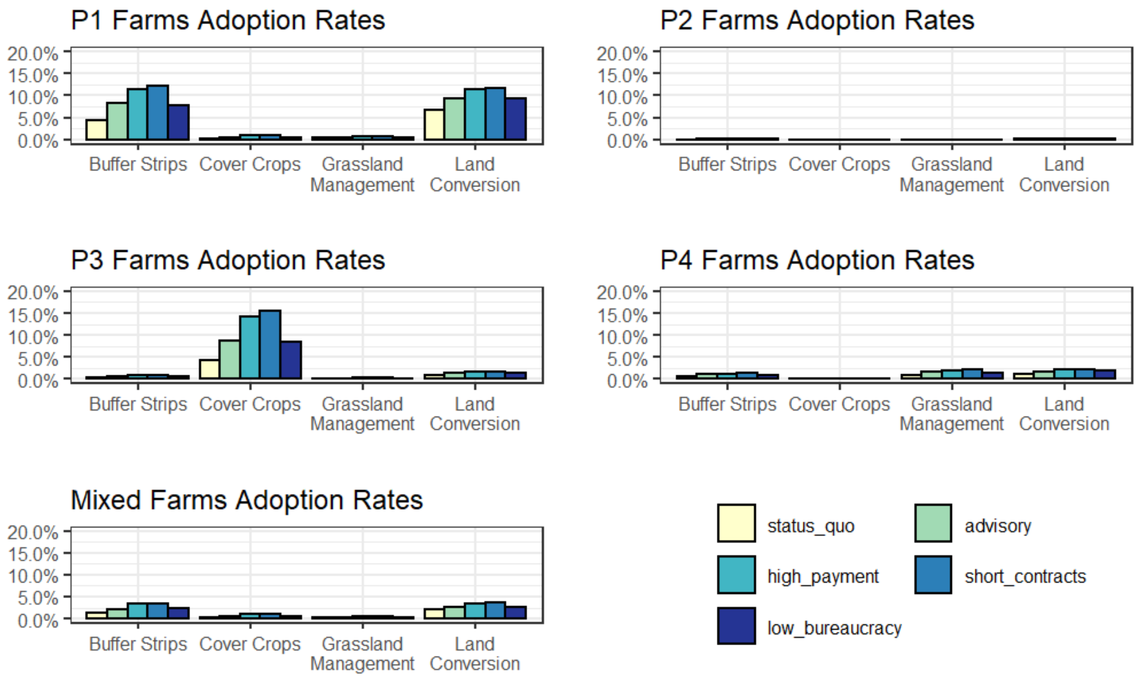

Figure 5.8. Adoption rates of the selected AES at farm level in the ES case study for different policy scenarios separated by farm specialisation (FSA)

5.6. RS Case Study

Figure 5.9 depicts the adoption rate for Backa CS as it varies by AES type. The effects of different policy scenarios can be observed. Since there are no AES in Serbia, in the "status quo" scenario, we offer farmers payments that were assessed by agro-economists in such a way that foregone income after applying an AES is null. Comparing the tested policies to the status quo, all have positive effects on adoption. The short contracts have the highest influence on the adoption increase, followed by high payments. Cover crops and flower strips are generally more popular schemes compared to land conversion and grassland maintenance. This stems from the fact that there are not many grasslands in the case study, and the farmers are more likely to choose the AES that fits better with their general practice.

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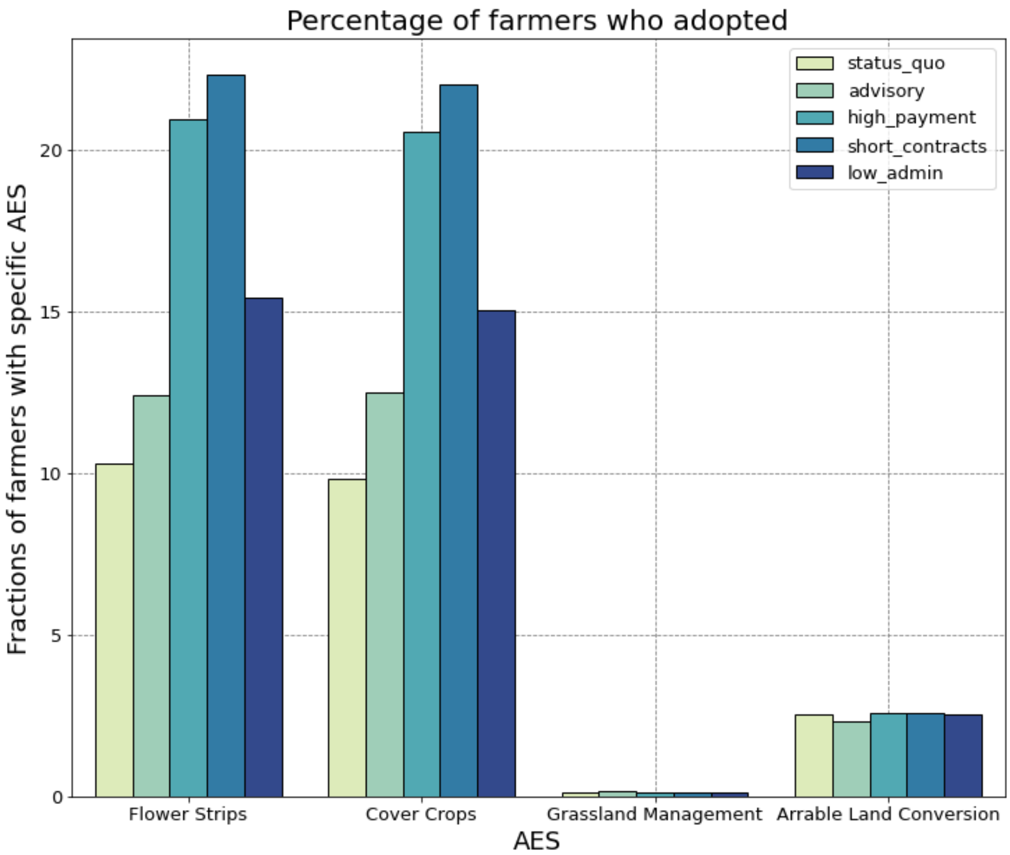

Figure 5.9. Adoption rates of the selected AES at farm level in the RS case study for different policy scenarios

Figure 5.10 shows adoption rates differentiated by farm categories. In the Backa CS, farms in the P1 category are dominant (>95% of the total sample). Nevertheless, different trends can be observed across the presented categories. Farmers that have grasslands are more likely to adopt the Grasslands Management AES. P1 farmers are more interested in AES for cover crops and flower strips, whereas P3 farmers are open to all available AES that are suitable to be applied in their fields. Across schemes, mixed farm types are generally more open to adopting different types of schemes.

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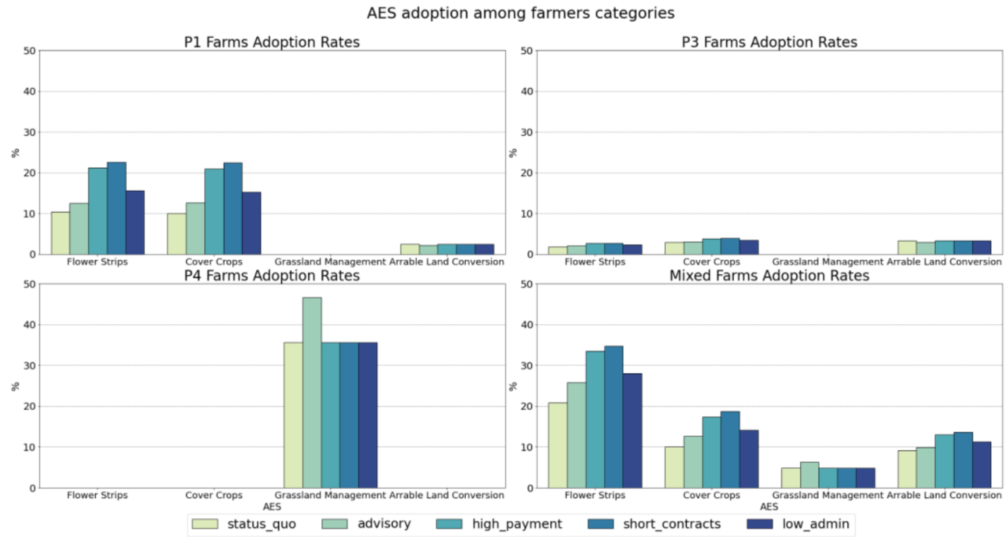

Figure 5.10. Adoption rates of the selected AES at farm level in the RS case study for different policy scenarios separated by farm specialisation (FSA)

5.7. Similarities and Differences

Across case studies we observed that offering AES with contract durations reduced to one year compared to the currently offered five years lead to an substantial increase in adoption rates. A similar effect was observed when increasing the compensation by 10%. Lowering the administrative effort associated with adopting a scheme as well as increasing the access to advisory support also has a positive impact on the adoption rates of AES. However, based on empirical evidence in the literature we assume that changing those two contract characteristics has a smaller effect on the expected payment level than decreasing contract duration. This is also reflected in the lower effect on the overall adoption rates. Furthermore, when considering an increase in access to advisory support, it also needs to be considered that general openness to participating in AES (step 1 of the ABM decision-making process) is also affected by access to advisory support. If advisory support leads to a decrease in openness (as for some AES in DE and CZ), increased access might have only marginal effects on the adoption rates.

As described in section 5.1, we calibrated the model to replicate the current adoption rates. However, this approach includes assuming values for the standard deviation of the normally distributed expected payment level. These assumptions are crucial for the changes in adoption rates with different policy designs. The wider the normal distribution the smaller the effects of e.g. a 5% in expected payment level. A complete analysis of the effects of different policy scenarios must therefore be combined with a sensitivity analysis to test the effect of different standard deviations. The results shown here can therefore only represent a small part of the possible effects on the adoption of AES by changing the contract conditions.

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