CONSOLE

CONtract Solutions for Effective and lasting delivery of agri-environmental-climate public goods by EU agriculture and forestry

Research and Innovation action: H2020 - GA 817949

Report on performance and design of collective approaches to AECPGs provision

Project	CONSOLE
Project title	CONtract Solutions for Effective and lasting delivery of agri-environmental-climate public goods by EU agriculture and forestry
Work Package	4 Simulations and performance of new contract solutions
Deliverable	D4.3
Period covered	
Publication date	Draft
Dissemination level	Public
Organisation name of lead beneficiary for this report	UNIBO
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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement GA 817949

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Table of contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement GA 817949

1 Summary

This deliverable summarizes the finding from the modelling exercises developed in "Task 4.4 Modelling collective approaches to AECPGs provision". Within the task, four models have been developed, all focusing on biodiversity protection, but with different perspectives. The models show that under certain conditions collective approaches can be more effective than traditional agri-environmental schemes. However, the specific design of the schemes and institutions implementing it matters for their effectiveness.

2 Introduction

Deliverable D4.3. reports on the modelling exercises and results related to "Task 4.4 Modelling collective approaches to AECPGs provision". The main goal of the task is to assess the performance of collective approach toward AECPG provision, and in particular: 1) to assess how collective implementation might emerge in different context, 2) how collective contracts are facilitated by public policies.

CONSOLE has developed 4 models in the task, focusing primarily on the provision of biodiversity conservation. The choice of focusing on biodiversity conservation is due to the fact that, according to stakeholders and to the relevant scientific literature, this is a key aspect for which collective implementation is strongly suggested to improve the current design of public policies. Indeed, biodiversity conservation in agricultural areas depends on environmental processes that work at the landscape scale and for which the spatial configuration of habitat plots is crucial (Lefebvre et al., 2015). In turn, this implies that targeting individual efforts might create mismatches between the scale of interventions and the scale of environmental process. Collective approaches that assume a landscape scale could in principle be more effective. The 4 models however focus on different aspects (Table 2-1).

Table 2-1. Overview of the key characteristics of the modelling exercises.

Model code	AECPGS	Key aspects covered
CO_UNIBO_1	Biodiversity	Assessment of agglomeration bonus under different assumptions on farmers' cooperative behaviour

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CO_UNIBO_2	Biodiversity	Assessment of agglomeration bonus design options
CO_TI_UNIBO	Biodiversity	Evaluation of agglomeration bonus in a realistic setting and landscape
CO_UNIFE_UNIPI_TI	Biodiversity	Evaluation of coordination device for collective approaches' toward AECPG provision

The first three models (CO_UNIBO_1, CO_UNIBO_2 and CO_TI_UNIBO) have in common a strong focus on one of the critical aspects of collective implementation, namely the specific choice by relevant decision-makers to cooperate/coordinate rather than acting individually. Moreover, the three models assess the relative effectiveness of the agglomeration bonus with respect to the traditional design of agri-environmental schemes. The agglomeration bonus is among the most prominent collective approaches toward biodiversity conservation that has been developed by the scientific literature (Nguyen et al., 2022). Such a scheme rewards the implementation of the connectivity among plots of land allocated to habitat. For example, a bonus is granted for each pair of neighboring plots that are both allocated to habitat.

The model CO_UNIBO_1 focuses on the assessment of the agglomeration bonus under different assumptions regarding the response of the farmers facing such a scheme. The model shows that assuming cooperation on land use by the farmers facing the scheme might cause an overestimation of the effectiveness of the agglomeration bonus. When the individual choice of cooperating is taken into account, the relative performance of the agglomeration bonus with respect to a standard homogenous payment is more nuanced. More specifically, if the assumption on full-cooperation is relaxed, the agglomeration bonus is more effective than the homogenous payment only for low level of public expenditures. The authors also show that the effectiveness of the scheme depends on the spatial distribution of the opportunity costs of habitat conservation (Bareille et al., 2022).

The second model, CO_UNIBO_2, extends the first model and focuses on the different potential designs of the agglomeration bonus. Six agglomeration bonus scenarios, generated by the combination of two contract parameters, are explored - in addition to the comparison with the homogenous payments. The first dimension that is analysed is what connections among plots are rewarded. In a *project* setting, it is assumed that farmers form groups and formulate projects that list the plots (and hence the connections) that are going to be implemented. In such a setting, only the *declared*

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connections are rewarded, whereas the connections that might emerge across different projects are not. This setting is probably the most realistic one. However, the authors compare it with an *ambient* setting. In the ambient setting, any connection among neighbouring plots is rewarded. This might create spatial spillovers due to land use and in principle might hinder cooperation among farmers, ultimately resulting into low effectiveness of the scheme. The second dimension is how farmers are allowed to answer to the scheme. Here four settings are considered: a) only single farmers can respond (no cooperation among them is envisioned), b) groups can respond and group membership is exclusive, c) groups can respond and group membership is open, d) full-cooperation. Such a variety of setting has not been explored yet by the literature and it provides a comprehensive view on the evaluation of different design options of the agglomeration bonus.

The third model, CO_TI_UNIBO, applies the theoretical framework developed by Bareille et al. (2022) to a real case study. The case study is located in Germany, and it is composed by the reference to a real policy scenario (the formulation of the eco-scheme and its combination with second pillar measures) and a real landscape. This represents one of the few examples on which the agglomeration bonus is tested (with simulation models) on a realistic setting (Drechsler et al., 2010).

The fourth case, CO_UNIFE_UNIPI_TI, is a modelling framework for the assessment of coordination devices that would help farmers to coordinate in case of collective approaches toward AECPGs provision (Villamayor-Tomas et al., 2019). Indeed, coordination is characterized by high transaction costs, that, in turn, might hamper its emergence and ultimately frustrate the attempts to implement collective approaches toward AECPGs provision. The case described here is an attempt to provide a modelling framework to assess a bridging institution, a platform, that provides a meeting device that cuts down transaction costs.

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3 Models' descriptions

3.1 Assessment of the effectiveness of the agglomeration bonus with an endogenous group formation modelling framework[1] (CO_UNIBO_1)

3.1.1 Introduction

One of the most severe criticisms on the current design of Agri-Environmental Schemes is that they potentially lead to a mismatch between the target of the incentives (the individual farms) and the scale of the environmental processes underlying biodiversity conservation (the landscape). To overcome these issues, it has been often suggested to design schemes that incentivize the coordination of the individual conservation efforts, so that a landscape scale approach is implemented and the potential mismatch between scale of intervention and scale of environmental processes are resolved.

To implement such a coordinated effort, the literature has suggested the implementation of the so-called agglomeration Bonus (AB) (Nguyen et al., 2022). An AB is a voluntary and spatially explicit scheme in which the connections among plots is rewarded in addition to the in-loco conservation effort itself. In addition to studies using experiments (see e.g. Banerjee et al., 2021), an increasing literature has assessed the cost-effectiveness of AB schemes using spatially explicit simulation model (e.g. Wätzold and Drechsler, 2014). In general, the literature suggests that indeed the AB scheme is more cost effective than the traditional AES design. However, most of these works assume that the population of farmers respond to the AB scheme in a cooperative manner. This is a reasonable but simplifying assumptions that might affect the result of the assessment exercise. Indeed, cooperation should be rather treated as a choice, given the potential mismatch between the individual and the collective optimum. This is the case especially if coordination is costly and hence farmers might prefer to enroll individually or in small groups.

Against this background, the objective of this work is analyzing the cost-effectiveness of an AB scheme using a coalition formation framework (e.g. Zavalloni et al., 2019) that enables to endogenize the choice of cooperating. We simulate through a

[1] This section is an extract of the article by Bareille, François, Matteo Zavalloni, and Davide Viaggi. 'Agglomeration Bonus and Endogenous Group Formation'. *American Journal of Agricultural Economics* n/a, no. n/a (online 2022). https://doi.org/10.1111/ajae.12305. More details on the model and on the results can be found in the article.

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spatially explicit mathematical programming model the farmers response to an AB scheme by modelling both the choice of land use, and the choice of cooperation, i.e., which groups are formed for a given set of AB parameters. We then compare the effectiveness of the AB with that of a traditional AES scheme incentivizing the individual efforts and with a setting characterized by the fact that cooperation is fixed rather than being endogenous.

3.1.2 Model description

3.1.2.1 Theoretical formulation

Imagine a regulator that can either design an AB scheme or a traditional AES scheme. The AB scheme rewards farmers with a flat rate *p* per each plot on which conservation efforts are undertaken ($x_{ij}^{S_m} = 1$). In addition to the flat-rate, farmers obtain a bonus *b* for each border between two conserved plots.

Assume that farmers enrolling in the AB scheme must formulate conservation projects that indicate both the farmers participating in the project and the plots that are conserved. Moreover, assume that only borders among plots that are indicated in the project are rewarded through the bonus *b*. The traditional AES lacks the bonus *b*, i.e. only the flat rate is offered to the farmers enrolling in the scheme. Furthermore, imagine that the landscape that is the target of the intervention is subdivided in a number of farmers I and that each of them own J plots of equal size.

To model the farmers' response to the scheme we use a coalition formation framework. Following this framework, the response is subdivided in two stages that are solved by backward induction. In the second stage, we evaluate the land use choice of each farmer in each possible combination of groups. We assume that each farmer decides on the land use by maximizing the aggregate utility of the group. Given the land use decisions, we compute the profits that each farmer obtains in each possible group of farmers. In the first stage, farmers will decide on whether it is profitable to being a member of a given group or they are better-off deviating and join another group. The ultimate result of the analysis is the set of the stable coalition structure, i.e. the grouping of farmers where no-one has incentives to change group membership. Mathematically, the description of the second stage is given by:

$$\max_{\mathbf{x}_i^{S_m}} \sum_{i \in S_m} u_i^{S_m} \qquad (1)$$

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With

$$u_i^{S_m} = \sum_{j=1}^{J}\left(x_{ij}^{S_m} \cdot p + \left(1 - x_{ij}^{S_m}\right) \cdot c_{ij}\right) + \sum_{j=1}^{J} \varphi_j^{S_m} \cdot x_{ij}^{S_m} \cdot q - \mathbf{1}_{|S_m| \geq 2}\left[C \cdot |S_m|\right] \tag{2}$$

where $u_i^{S_m}$ indicates the utility that a farmer obtains when she is a member of coalition S, $\varphi_j^{S_m}$ is a function that counts the adjacent conserved plots around plot j and that are in the same conservation project, and C is coordination costs dependent on the size of the coalition.

In the first stage we assume that coalition formation is characterized by exclusive membership. This means that member of a group can deny the access to additional members. For any partition of farmers, a stable coalition structure means 1) no farmers have incentive to become a singleton or that is not excluded by the other members, and 2) no farmer has incentive to join another coalition or that she will be denied access by the coalition members.

To evaluate the effectiveness of the AB and AES scheme, we compute the biodiversity function of the area given the resulting land use decisions in the stable coalition structures. Following Wätzold and Drechsler (2014), we define biodiversity $B(\mathbf{x})$ as:

$$B(\mathbf{x}) = \sum_{i=1}^{I}\sum_{j=1}^{J} x_{ij} \cdot \sum_{k=1}^{I}\sum_{\substack{l=1 \\ l \neq j \text{ if } k=i}}^{J} x_{kl} * \exp\left(\frac{-d_{jl}}{D}\right), \tag{3}$$

Where, d_{jl} is the distance between the centroids of the two different plots j and l and D is the dispersal rate of the considered species. The dispersal rate is a measure of the capacity of a given species to move across the habitat of a landscape. Holding the same total size of habitat, biodiversity decreases with an increase in the distance between conserved plots. Public expenditures are defined as the sum of the total payments attributed to landowners in the stable coalition structures. Formally, public expenditures for a given stable coalition structure are: $P = \sum_{S_m \in \pi_k} \sum_{i \in S_m} \sum_{j=1}^{J} \left(x_{ij}^{S_m} \cdot p\right) + \varphi_j^{S_m} \cdot x_{ij}^{S_m} \cdot q$, i.e. the sum of the payments attributed to each landowner in each coalition of a stable coalition structure.

3.1.2.2 Numerical implementation

The model described in the previous section has been numerically implemented in GAMS. We create a number of fictious landscapes composed by 9×9=81 plots

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subdivided in 9 farmers. As the number of players is 9, there are M=29-1=511 coalitions and K=B9=21,147 coalition structures. We randomized the costs associated to habitat conversion to habitat, constraining the spatial cost dispersion to different degrees of spatial auto-correlation (measured by the Moran's I).

3.1.3 Results

Figure 3-1.a shows that increasing the bonus element of the AB scheme fosters cooperation among farmers. The average size of the coalition in stable coalition structures increases, with an average maximum of 3 at around 50€ per border.

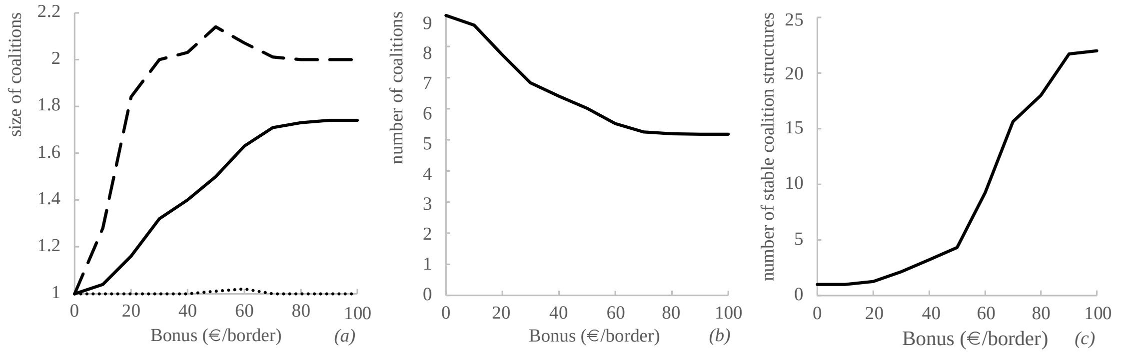

Figure 3-1.Cooperation outcomes according to the bonus levels: (a) average (solid line), minimum (dotted line) and maximum (dashed line) number of landowners within an average stable coalition (constituting the average stable coalition structure), (b) average number of coalitions per stable coalition structure, (c) average number of stable coalition structures per landscape. The simulations were performed using p=€80/ha, D=2 and C=0. The outcomes are computed as averages over all the stable coalition structures of the 61 simulated landscapes. Source: Bareille et al. (2022).

Figure 3-2 shows that Increasing bonus levels not only translate in higher cooperation but also in higher habitat size *(2.a)* and ultimately in higher biodiversity *(2.b)*. Figure 3-2 shows also that assuming cooperation, rather than addressing it as a choice, leads to an *overestimation* of both habitat and biodiversity per bonus level.

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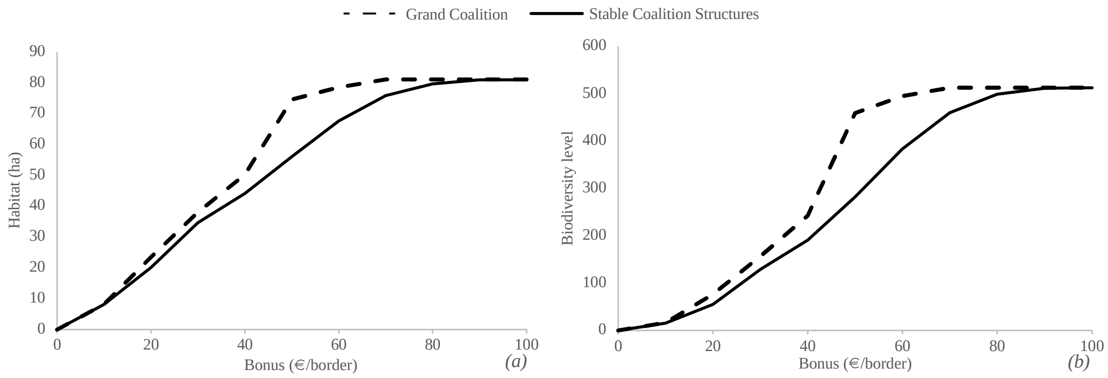

Figure 3-2. (a) habitat area and (b) biodiversity levels as a function of the bonuses in the GC and in the stable coalition structure. The simulations were performed using p=€80/ha, C=0 and D=2. The outcomes are computed as averages over all the stable coalition structures of the 61 simulated landscapes. Source: Bareille et al. (2022).

In Figure 3-3.a we compare the outcome in terms of biodiversity per public expenditures of three settings: i) the results of the AB considering an endogenous coalition formation setting, ii) the results of the AB considering aa full cooperation setting and iii) the results from a homogenous payment. Three are the main findings from the figure. First, assuming full cooperation among players leads to an overestimation of the effectiveness of the AB. For any expenditure level, the biodiversity generated by the full cooperation setting is greater than the one generated assuming a coalition formation perspective. Second, when assuming that coalitions are formed in response to the scheme, the AB instrument is more cost effective than the homogenous payment, but only for relatively low level of public expenditures. for high level of public expenditures, homogenous payments are superior. When high expenditures can be put into place, high levels of habitats are implemented, and connections emerge across plots even of the scheme is not designed to do so. Third, the threshold above which the homogenous payment is more effective than the AB reduces with the increase in the spatial cost autocorrelation (Figure 3-3, panels c to d).

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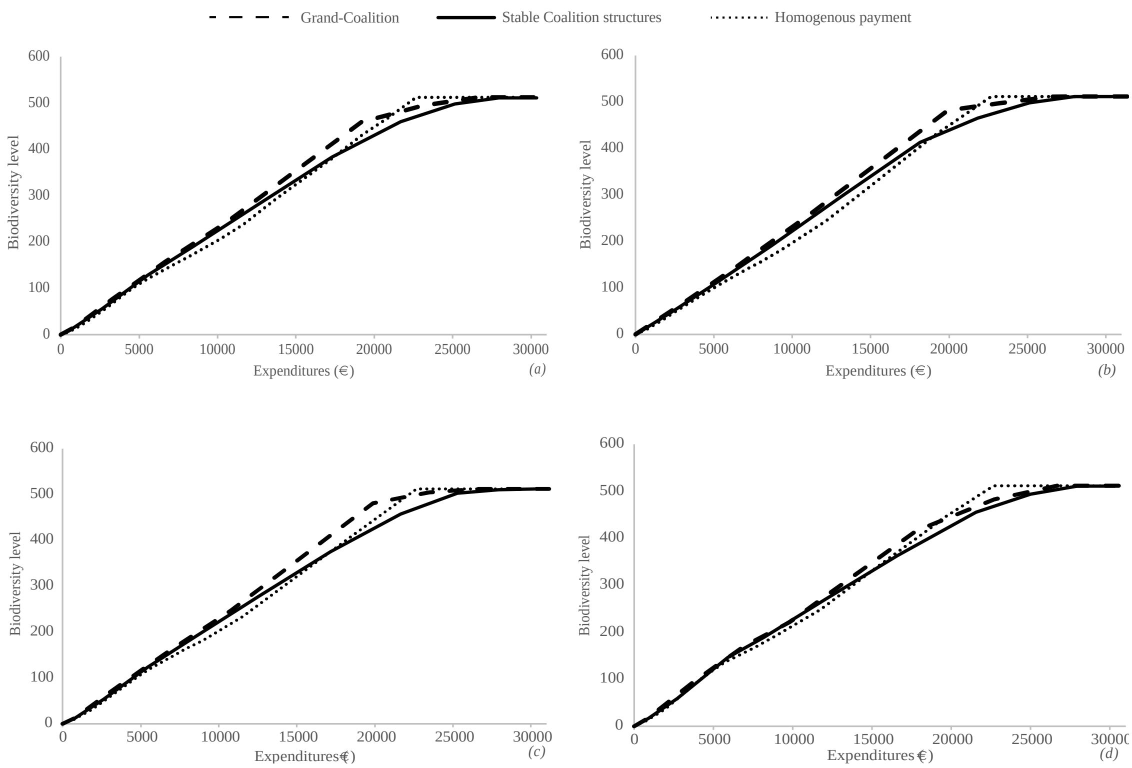

Figure 3-3. Biodiversity levels as a function of the aggregated expenditures (in €) under spatially homogeneous payments (dotted line), AB with the GC (dashed line) and AB with endogenous coalition formation (solid line) in (a) the average over all landscapes, (b) the landscapes with Moran's I between 0.5 and 0.6 (b) the landscapes with Moran's I between 0.6 and 0.7 and (d) the landscapes with Moran's I between 0.7 and 0.8. The simulations were performed using p=€80/ha, C=0 and D=2. The outcomes are computed as averages over all the stable coalition structures of the 61 simulated landscapes. Source: Bareille et al. (2022).

3.1.4 Discussion and concluding remarks

In this paper, we theoretically assess the cost-effectiveness of AB schemes in case landowners decide on both land use patterns and with whom to cooperate in response to the schemes. In contrast to most of the literature, we endogenize the choice of cooperating of farmers facing an AB scheme. The results indicate that indeed the AB is more effective than traditional homogenous payments. However, we find that this is the case especially when public expenditures are relatively low. When this is not the case, homogenous payments are likely to be more effective than AB schemes. Moreover, we find that modelling assumptions matter for the assessment of the relative effectiveness of the AB. Indeed, the results in terms of effectiveness change depending on whether cooperation is

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assumed or not, hinting at the fact that this kind of instruments need more complex modeling setup than the traditional homogenous payments.

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3.2 The design of the agglomeration bonus (CO_UNIBO_2)

3.2.1 Introduction

An increasing literature assesses the advantages of implementing collective approaches toward biodiversity conservation in working landscapes. Coordination on the implementation of conservation efforts among independent landowners is supposed to improve the effectiveness of agri-environmental schemes (AES). Indeed, traditional AES target individual farms, hence potentially creating a mismatch between environmental processes (that work at the landscape scale) and the environmental interventions.

In the literature, the Agglomeration Bonus (AB) is among the most prominent collective schemes (Nguyen et al., 2022). The AB is a specific form of AES, where, in addition to the standard payment that incentivizes the implementation of conservation effort, a bonus is granted in case the efforts are spatially clustered. Despite the many researches on the topic, the design of AB is still to be exhaustively evaluated. With few exceptions (Bareille et al., 2022; e.g. Bell et al., 2016), in most of the simulation models, farmers responding to the AB are assumed to cooperate and land use decisions are taken as to maximize the aggregate utility (Wätzold and Drechsler, 2014). In such a case, many design elements are irrelevant in the evaluation of the AB as they only affect individual payoffs and the farm-level decisions to cooperate.

In this paper we analyze, by using a spatially explicit mathematical programming model, different design of the AB in a setting where farmers take both the decision on land use and cooperation. We enlarge the scope of the analysis of Bareille et al. (2022) while keeping the coalition formation framework that is the core of their work. First, we analyze both a *project* and an *ambient* AB design. In a project design, landowners are rewarded for the connections that are declared in a conservation project, that lists booth the plot allocated to habitat and the players. In an ambient setting, players are rewarded for any connections among plots that emerge from any land use decision. Second, we analyze different setting with respect to the formation of cooperating groups. Two are the settings: open membership (OM) and exclusive membership (EM). The main difference between the two setting is that in EM players are able to exclude newcomers from joining a group, whereas in OM players do not have this power. Third, we analyze also a setting where groups are not allowed to form, and only individual farms can enroll into the scheme. Finally, we compare these designs with a setting where farmers are assumed to cooperate and with a traditional homogenous payment

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3.2.2 Model description

Imagine a landscape composed by several plots of equal area that are owned by a population of farmers, owning an equal share of the landscape. Cal P^{IB} a standard per-area homogenous payment and P^{AB} a bonus that rewards the connections among plots allocated to habitat. For each plot *i*, the reward from conservation is given by:

$$U_i^{AB}(X_i = 1) = P^{IB} \cdot X_i + P^{AB} \cdot X_i \cdot \sum_{\substack{k \neq i \\ k \in \Phi_i}} X_k \tag{1}$$

where Φ_i represents the subset of neighbouring plots that, if also allocated to habitat, create the connections that are rewarded by the AB scheme. Note that by setting $P^{AB} = 0$, we are in the classic, spatially homogenous AES scheme. The difference between the *project* and the *ambient* design of AB lies in the definition of Φ_i. In the case of the project setting, the neighboring plots are those within a certain range and must belong to the farmers coordinating together in the same group (S) $\Phi_i = \{k \in Ij | d_{ik} \leq \bar{d}, j \in S\}$. In the case of ambient setting, the neighboring plots can be any plot within a certain distance, with no further qualification: $\Phi_i = \{k | d_{ik} \leq \bar{d}\}$. In other words, the project AB rewards the declared connections, whereas the ambient AB rewards any connection.

In addition to the ambient and project settings, we also explore different design with respect to the participation of the farmers in the AB scheme. The enrollment in the scheme is modelled with a coalition formation game that is solved by backward induction (Bareille et al. 2022). In the second stage, we assume that farmers decide on the land use to maximize the aggregate utility of the group they belong to. Mathematically, land use decision is taken according to:

$$\max_{X_{i \in I_j}} \sum_{j \in S} \Pi_j^{AB,S} \tag{2}$$

Where the utility of each coalition members is given by:

$$\Pi_j^{AB,S} = \sum_{i \in I_j} \left[P_i^{AG} \cdot (1 - X_i) + P^{IB} \cdot X_i + P^{AB} \cdot X_i \cdot \sum_{\substack{k \neq i \\ k \in \Phi_i}} X_k \right] - C \cdot |S| \tag{3}$$

and C indicates the coordination cost associated to the number of people cooperating. In the first stage groups of farmers cooperating in response to the AB are formed. Call Ω the configuration of a given coalition structure, i.e. the partition of farmers in different

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groups. Moreover, denote S and Z with $S \cap Z = \emptyset$ the composition of two coalitions being in the configuration of a given coalition structure Ω. We drop for simplicity the superscript AB and indicate by Π_j^S the utility of farmer *j* being member of coalition *S*, and Π_j^f the utility of farmer *j* being in the special case of behaving a singleton (not cooperating). In EM, the coalition structures that are stable, Π^*, meet the following conditions:

$$\Pi_j^S \geq \Pi_j^f \wedge \Pi_k^S \geq \Pi_k^{S-j} \quad \forall S \in \Omega \text{ and } \forall j,k \in S \tag{4}$$

$$\Pi_j^S \geq \Pi_j^{Z+J} \vee \Pi_k^Z \geq \Pi_k^{Z+J} \quad \forall S,Z \in \Omega \tag{5}$$

In OM, the coalitions that area stable meet the following conditions:

$$\Pi_j^S \geq \Pi_j^{Z+J} \; \forall j \in S, \forall S,Z \in \Omega \tag{6}$$

The difference between the two membership types is given by the fact that in EM farmers have the power to exclude new members if they find it profitable. This is evident by the second terms in equations (4) and (5).

Overall, combining the different scheme designs, we evaluate 7 policy scenarios that are listed in Table 3-1.

Table 3-1. Description of the AB scenarios and definition of the contract parameters

AB design	Definition of neighbors	Participation definition
Ambient non-cooperative	$\Phi_i = \{k \mid d_{ik} \leq \bar{d}\}$	irrelevant
Ambient SCS - OM	$\Phi_i = \{k \mid d_{ik} \leq \bar{d}\}$	Eq (6)
Ambient SCS - EM	$\Phi_i = \{k \mid d_{ik} \leq \bar{d}\}$	Eq (4) and (5)
Project non-cooperative	$\Phi_i = \{k \in Ij \mid d_{ik} \leq \bar{d}, j \in S\}$	irrelevant
Project SCS - OM	$\Phi_i = \{k \in Ij \mid d_{ik} \leq \bar{d}, j \in S\}$	Eq (6)
Project SCS - EM	$\Phi_i = \{k \in Ij \mid d_{ik} \leq \bar{d}, j \in S\}$	Eq (4) and (5)
Grand coalition	irrelevant	irrelevant

To evaluate the relative effectiveness of the different policy scenarios, the following concepts are used. First, we compute the biodiversity function of the area given the resulting land use decisions in the stable coalition structures. Following Wätzold and Drechsler (2014), we define biodiversity $B(\mathbf{x})$ as:

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$$B(\mathbf{x}) = \sum_{i=1}^{I} \sum_{j=1}^{J} x_{ij} \cdot \sum_{k=1}^{I} \sum_{\substack{l=1 \\ l \neq j \text{ if } k=i}}^{J} x_{kl} * \exp\left(\frac{-d_{jl}}{D}\right) \quad (7)$$

where, d_{jl} is the distance between the centroids of the two different plots j and l and D is the dispersal rate of the considered species. The dispersal rate is a measure of the capacity of a given species to move across the habitat of a landscape. Holding the same total size of habitat, biodiversity decreases with an increase in the distance between conserved plots.

Given the biodiversity we define three types of effectiveness. The first one is the expenditure-effectiveness, which is biodiversity level per expenditure level. Expenditure is defined as the sum of the total payments attributed to landowners in the stable coalition structures. Formally, public expenditures are: $E = \sum_i P^{IB} \cdot X_i + P^{AB} \cdot X_i \cdot \sum_{\substack{k \neq i \\ k \in \Phi_i}} X_k$.

The second criteria is cost-effectiviness, which is biodiversity level per level of the aggregate opportunity costs of habitat conservation. Costs are then defined as $K = \sum_i P_i^{AG} \cdot (1 - X_i)$. The final criteria is budget effectiveness. This is defined as maximum allowable expenditures that are envisioned given certain payment levels. Mathematically, $G = P^{IB} \cdot I + P^{AB} \cdot \Phi$ qwhere I and Φ are respectively the total number of plots and of connections among them in the given landscape. Note that through the budget we can link to the same dimension the AB level and the homogenous payments, that would otherwise refer to different element. For example, assuming an AB scheme with $P^{AB} = 10$ and $P^{IB} = 0$, and 7 plots and 14 connections, we would have $G = 140$. This AB design is equivalent in terms of maximum allowable expenditures to a scheme with $P^{AB} = 10$ and $P^{IB} = \frac{140}{7} = 20$€/ha.

The model described in the previous section has been numerically implemented in GAMS. We create 50 fictious landscapes composed by 133 plots subdivided in 7 farmers. We randomized the costs associated to habitat conversion to habitat, constraining the spatial cost dispersion to different degrees of spatial auto-correlation (measured by the Moran's I).

3.2.3 Results

3.2.3.1 Project design

The first set of graphs (panels A1 to A3) of Figure 3-4 shows the relative performance of the different policy scenarios in term of habitat conservation. For any

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budget, cost and expenditure level, the homogenous payment scenario leads to the highest area allocated to habitat. For the same levels of either budget, costs or expenditures, the AB policy scenarios do not reach the maximum allowed habitat size. The differences among the AB designs are minimal. The greatest differences among the policy scenarios are displayed when budget is taken into account (panel A1).

Another major difference between the homogenous payment scenario and the AB scenarios is found when looking at the average costs of the conserved plots (panes B1 to B3). When considering both average costs per total costs and per expenditures, the homogenous payment selects the cheapest plots on average. As before, the differences among the AB scenarios are small. Indeed, the AB scheme (irrespectively on the design parameters) rewards the connections among the parcels, and the plot level opportunity costs are less relevant for the plot enrolment than in the case of the homogenous payments. The result is the enrolment of more expensive plots that are necessary to implement the connections that are actually rewarded.

Looking at the connectivity of the landscape (panels C1 to C3), the AB does indeed create clusters of habitats with higher connections than the homogenous payment. As for the previous elements, the main difference lies between on the one hand the homogenous payment, and on the other hand the AB policy scenarios.

The ultimate outcome is the biodiversity that is achieved under the different policy scenarios (panels D1 to D3). When looking at the cost-effectiveness, the homogenous payment is the worst policy design. Moreover, the graphs shows that cooperation pays for the evaluation of the AB. Among the AB scenarios, the most performative one is the full cooperation, there are small differences between OM and EM, and least performative is the non-cooperative setting. When considering the expenditure-effectiveness, things are more complicated, even though the differences are small. The full cooperation AB scenarios is the most performative designs. However, for low and high levels of public expenditures the homogenous payment seems to lead to higher biodiversity levels than the AB in case of OM, EM and no-cooperation. The highest differences between the policy scenarios can be found in term of budget effectiveness. For low levels of budget, the homogenous payment is most performative. Even for low level of payments (and hence, budget), the homogenous payment is able to convert plots into habitat. For the AB, relatively higher levels of payments (and hence budget) are required for the conversion to habitat. Indeed, given it design, the AB scheme is highly non-linear, with jumps from

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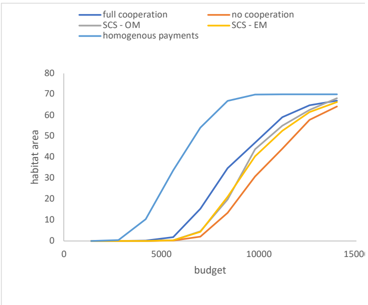
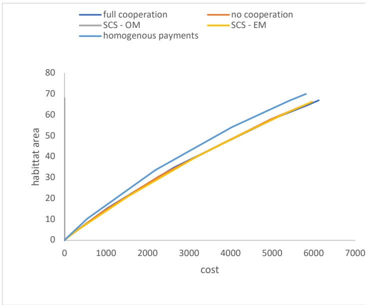
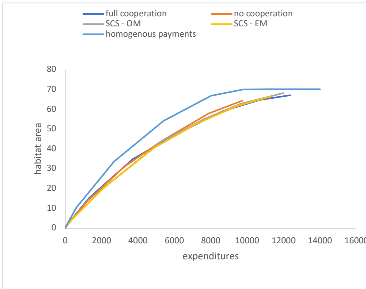
no-conversion to conversions at higher levels of payment rates than the homogenous payments. Recall that the budget effectiveness considers biodiversity level per the maximum allowable budget given payment. This budget is never reached under the AB, and indeed in terms of expenditure-effectiveness the AB is superior to the homogenous payment.



(A1)



(A2)



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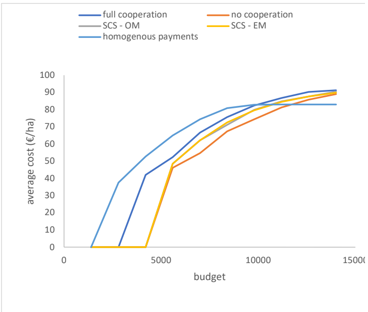
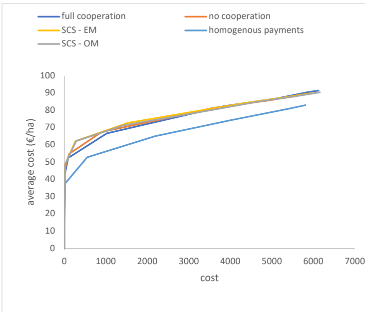
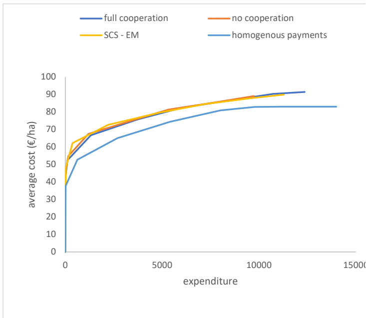


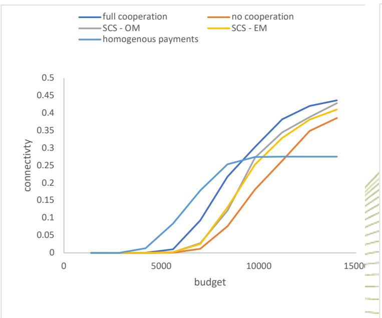
(B1)



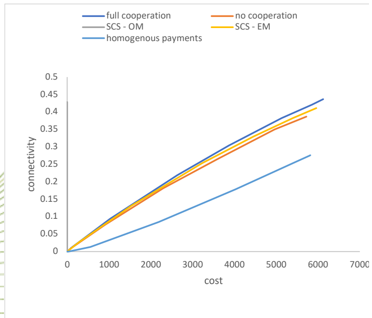
(B2)



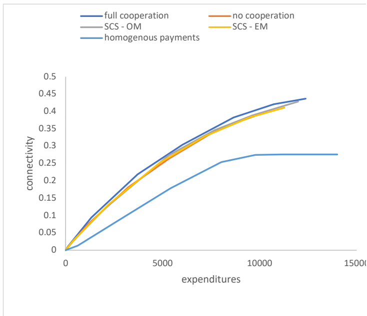
(B3)



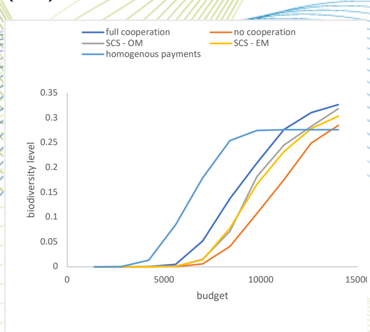
(C1)



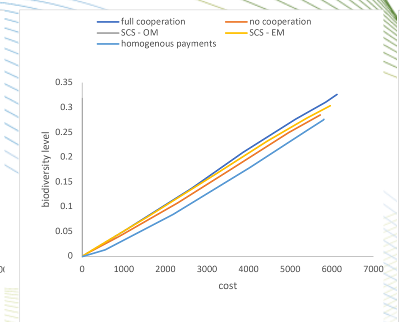
(C2)



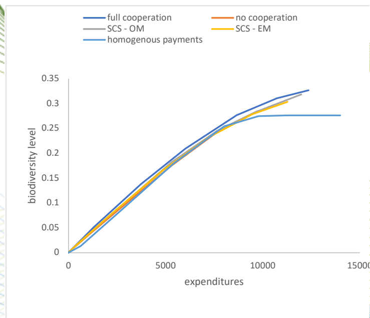
(C3)



(D1)



(D2)



(D3)

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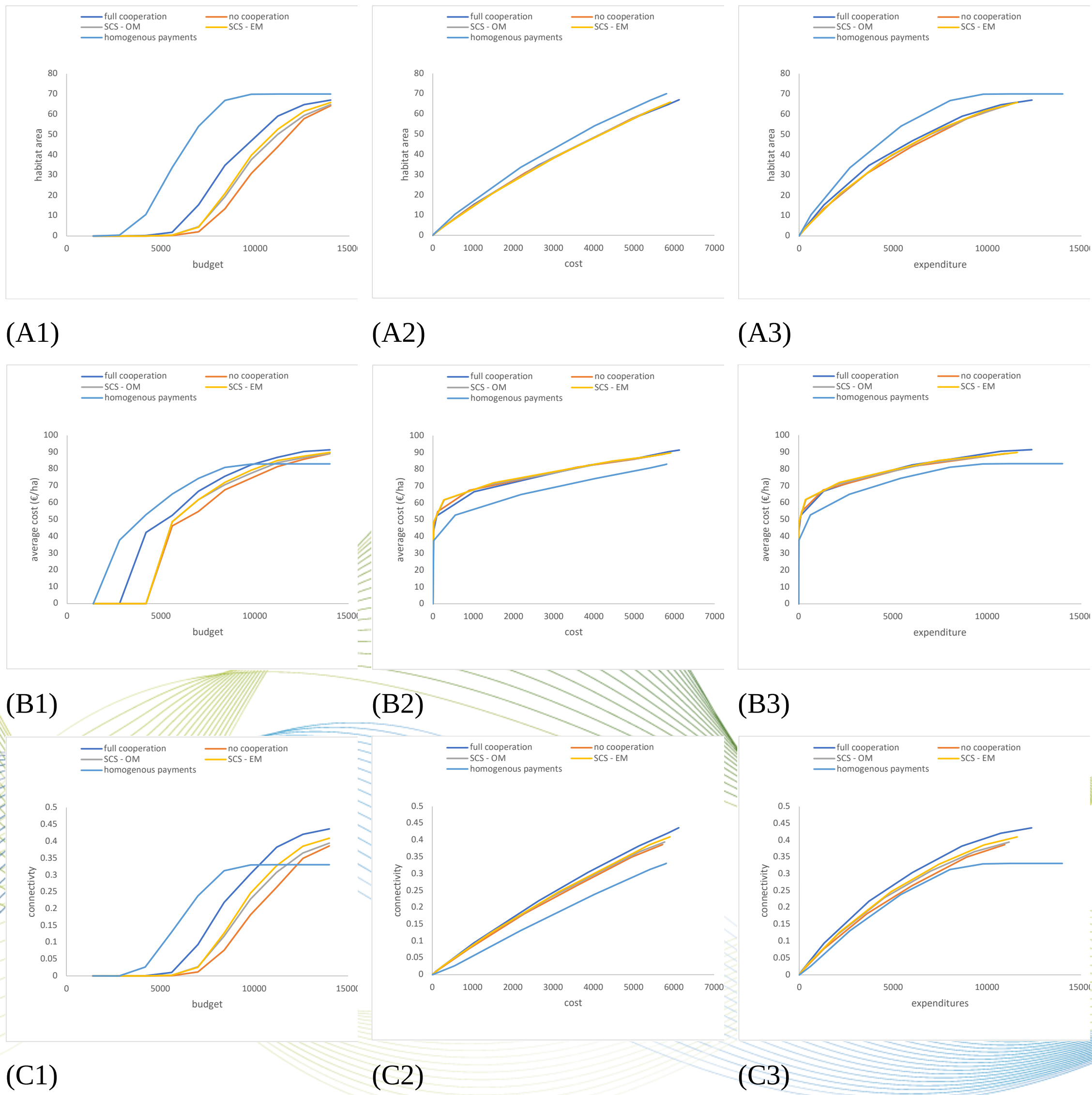
Figure 3-4. Results for the project AB design in terms of habitat area (Panels A), average costs per plot allocated to habitat (Panels B), connectivity among habitat plots (Panels C) and biodiversity (Panels D).

3.2.3.2 Ambient design

Figure 3-5 displays the results for the ambient AB design. There are no major differences with respect to the project AB design. The homogenous payment is able to enroll a higher number of plots than any AB policy scenario (panels A1 to A3). However, the AB scenarios enroll more expensive plots on average (panels B1 to B3) that are necessary to create clusters of habitat. The resulting landscape patterns create a higher level of connectivity among plots allocated to habitat than in the homogenous payment scenarios (panels C1 to C3).



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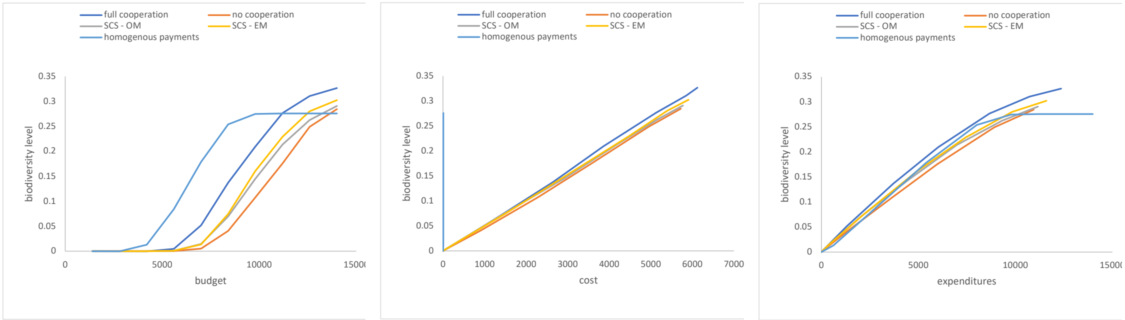

(D1) (D2) (D3)

Figure 3-5. Results for the ambient AB design in terms of habitat area (Panels A), average costs per plot allocated to habitat (Panels B), connectivity among habitat plots (Panels C) and biodiversity (Panels D).

3.2.3.3 Comparisons between project and ambient AB design

Figure displays how the increase in the AB levels affects cooperation among players in the project (panel A) and ambient (panel B) AB design. Two are the major differences between the two designs. First, the project design causes the largest average coalition size within the stable coalition structures. Second, in the ambient design, the relationship between average coalition size within the stable coalition structures is decreasing after a given threshold. These differences are due to the fact that the ambient design create some spatial spillover effects. Recall that in the ambient design, the reward among connections occurs between any plot allocated to habitat, even among plots that belong to different coalition. Cooperation is then relatively less important than in the case of the project design, where only through common projects, connections are rewarded by the AB scheme. Similarly, for high level of AB, large clusters of habitats is created even without cooperation. In such a case, in the ambient design, coalition structures composed by large coalitions become non-stable, as they are characterized by the high coordination costs and no benefits in terms of enrollment.

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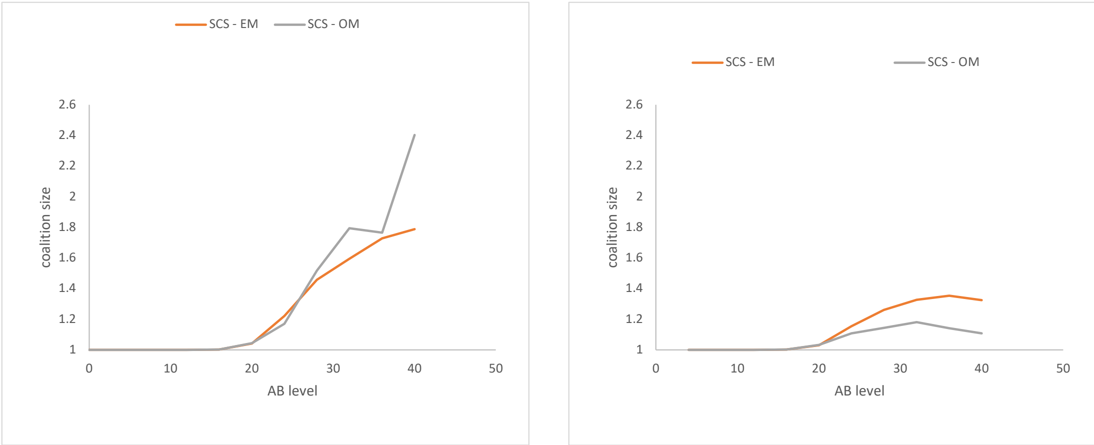
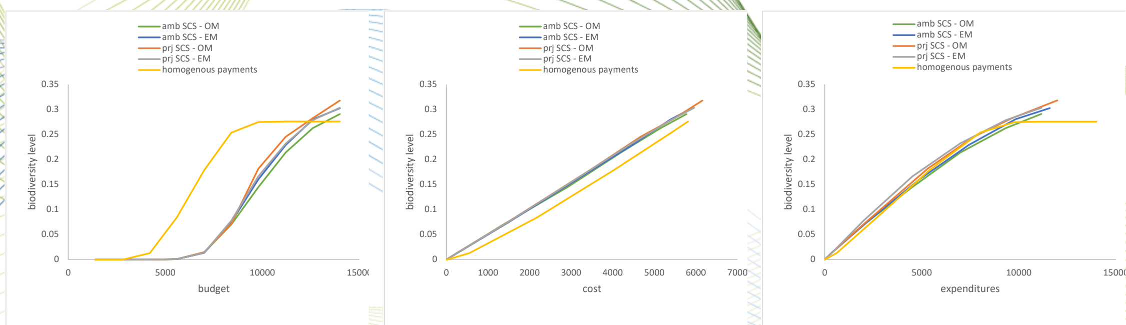


(A) (B)

Figure 3-6. Coalition size per different levels of AB under project (panel A) and Ambient (panel B) design and EM (grey lines) and OM (red lines).

The effect of the AB on the coalition formation translates also in differences with respect to the effectiveness of the policy scenarios. In Figure 3-7 we reproduce the budget (A1), cost (A2) and expenditure effectiveness (A3) for both the project and ambient design under OM and EM. When looking at the budget effectiveness, indeed the ranking among the different AB scenarios shows that the project design coupled with OM is the most performative design, with a ranking that mirrors the effect on the average coalition size within the stable coalition structures. Note again that the homogenous payment however is the most performative design for a large range of budget levels. In terms of cost-effectiveness, the AB designs do not display major differences among the scenarios, and they are always superior to the homogenous payments. Finally, in terms of expenditure-effectiveness, the AB with the project and EM setting is the most performative for low levels of public expenditures. Increasing such a level reduced the differences among the policy scenarios, up to a level where the larger cooperation ensured by OM setting makes it the most expenditure-effective.



(A1) (A2) (A3)

Figure 3-7. budget, cost and expenditure effectiveness for ambient and project AB design in OM and EM, and for the homogenous payment design.

3.2.4 Discussion and conclusion

Despite an increasing literature, the design of AB schemes has been not exhaustively covered. In this work we enlarge the scope of the analysis by Bareille et al. (2022) to evaluate the effectiveness of different AB design: project and ambient AB, coalition formation with open and exclusive membership, no cooperation and full cooperation and the standard homogenous payment.

The results indicate that irrespectively on the design, the AB generate smaller but more clustered habitats than the homogenous payments. In terms of biodiversity however, the effectiveness depends on the dimension that is taken into account and on the design.

The work also indicates the importance of the modelling assumption for the evaluation of the performance of the AB. Similar to Bareille et al. (2022), we also find that simply assuming full-cooperation among players could lead to an overestimation of the effectiveness of the AB. When relaxing these assumptions, differences among modeling assumptions are more nuanced, even though they still matter.

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3.3 Collaboration amongst farmers to increase the ecological effectiveness of fallow land for farmland birds (CO_TI_UNIBO)

3.3.1 Introduction

The Common Agricultural Policy (CAP) of the European Union strongly affects agricultural land uses and hence farmland biodiversity. With the abolishment of the mandatory set-aside in 2007 the share of fallow land dropped in Germany from more than 5 % to less than 2 % and since then remained at a low level (Röder et al., 2022). In 2019 the overall share of arable land left fallow was only 3 % (DeStatis, 2022). This had a strong impact on farmland bird populations (Hertzog et al., in prep). Chances and potential of collaborative approaches are discussed at national level (e. g. WBAE, 2019), yet there is little practical experience. Under the CAP for 2023-2027 the establishment of non-productive areas (NPA), will become mandatory within the so-called conditionality which will lead to an increase of fallow land in arable landscapes. In addition, an eco-scheme measure has been designed to extend the area to up to 10 % on a voluntary basis.

Taking this new situation as starting point, we will assess if an incentive to collaborate across farms in view of placing NPAs in a spatial context through a dedicated agri-environment payment, can increase the ecological value of NPA as a habitat by reducing fragmentation. We will use the grey partridge (*Perdix perdix*) and the northern lapwing (*Vanellus vanellus*) with their specific habitat requirements as example species. We will therefore focus on two different bonus payment designs, namely the agglomeration bonus and the threshold bonus, with respective advantages for the two species. The baseline scenario is established according to the CAP rules in the upcoming CAP period. The spatial explicit ecological-economic model is based on cost assumptions derived from real land use data and habitat information for three regions in Germany. It is expected that the performance of both bonus payment designs will vary across these regions which differ in their arable land use pattern and productivity.

3.3.2 Model description

Various scenarios will be modelled to assess cost and surface of NPA resulting from the conditionality obligation, the voluntary eco-scheme and with and without bonus payments by farmers. The following research questions are guiding the approach:

- Can a bonus payment for spatial coordination and collaboration of farmers increase the ecological effectiveness of NPAs?

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- What would be the required budget to achieve collaboration of farms in different regions in Germany?
- Does the bonus result in an increase of ecological valuable habitats compared to the same funding budget without spatial coordination incentives?
- Does the performance of the bonus payment approaches vary across regions?

3.3.2.1 Theoretical framework

The model is formulated in GAMS (GAMS Development Corporation, 2021) following the approach presented by Bareille et al. (2022). The response of the farmers to a collective incentive is modelled by introducing a land allocation model into a coalition formation game. The game is composed by two stages. First, the allocation of NPA by each farm that maximizes the aggregate utility of the farmer within a given coalition. For different payment scenarios, with and without payments for collaboration, the location of the NPAs is determined. We assume that farmers behave as profit maximisers within the circumstances of NPA requirements of conditionality and eco-schemes respectively. In a second step, for each bonus payment design the stable grouping of farmers, e.g. the farmers configurations for which there are no monetary incentives to change their participation or non-participation in coalitions, are found. The model simulates the short-term decision process of each farm within one year on the basis of land use data from 2018. A study area consists of about 1000 ha, representing all arable fields of several farms within a given spatial context. These farms are split into several randomised clusters that are composed by a maximum of 5 to 7 farms, depending on total number of farms per area.

In the baseline scenario the basic requirement of conditionality and the staggered payment for eco-scheme NPA are introduced. Furthermore, the two distinct bonus payment scenarios will be modelled, one for the agglomeration bonus and one for the threshold bonus. In the agglomeration bonus scenario, farmers will receive the bonus payment for neighbouring land parcels. The payment will be measured in EUR per ha, with a fixed bonus payment rate for each hectare that is connected to at least one more hectare of habitat (= NPA). For the threshold bonus scenario, target areas will be defined. As soon as two or more farms place NPA within the target area and thus reach a defined threshold of NPA, each of the farms receives a bonus payment, measured in EUR per ha

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as well. Both scenarios will be modelled in multiple variations for differing bonus payment rates, separately for each region.

The modelling will provide results on how the assessed policy instruments affect land use, the necessary payment levels and the creation of habitats for farmland biodiversity. It will give us information on the potential uptake of the voluntary eco-scheme for the establishment of NPA with and without collaboration amongst farmers and if the bonus payment approach for collaboration of farmers is an appropriate and efficient policy instrument to increase their ecological value.

In general, for our model species, the habitat quality is increased, when NPA (=habitat) is agglomerated (agglomeration bonus) or accumulated (threshold bonus). The objective is to determine the needed budget to enhance the ecological benefits by collaboration of farms. Contrasting the ecological value of the same budget with and without collaboration requirements will allow to evaluate the potential of coalition formation among farms, stimulated by bonus payments.

3.3.2.2 Empirical implementation

As the arable landscape of Germany has great differences across the nation, three federal states have been selected covering several gradients of landscape and farming metrics such as average field size and farm size. The selected federal states are Brandenburg, Lower Saxony and North Rhine-Westphalia. Search areas were selected on the basis of the occurrence of the two examples species farmland bird species, partridge and lapwing. Farms are selected in the target areas covering around 1000 ha of arable land. For all grid cells (hexagon-shaped parcels of 1 ha size) site-specific gross margins are calculated making use of IACS data for the cultivated crops and published data of yields and input per administrative region as well as machinery costs with respect to farm- and field specific characteristics (farm size, distance from field to farm, potential usage of silage maize for biogas plants). As the implementation of NPA completely prohibits any yields from the respective fields, we assume the opportunity costs to be directly derived from gross margins.

In the Strategic Plan for the Federal Republic of Germany (BMEL, 2022) it is foreseen that 4% of the arable land must become NPA at farm level without compensation payment in order to be eligible for direct payments in future. Only farmers that comply with this obligation, can on a voluntary basis participate in an eco-scheme measure where

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they establish NPA on up to additional 6 percent of their arable land. They get a decreasing staggered payment. The payment levels are 1300 EUR/ha for the first additional percent, 500 EUR/ha for a further percent and 300 EUR/ha for up to four further percent. No payments are made for NPA established above the 10 % limit to avoid abandoning too large areas in marginal areas.

We expect the results to vary between study regions which differ in farm size and the heterogeneity of costs for establishing habitats. The region-specific cost structure, determined by cultivated crops, yields and other parameters, is assumed to have an impact on the number and location of the habitats and thus on the effectiveness of bonus payments. The bonus payments will only have the desired effect of re-allocation of habitats, if the payment is high enough to cover the cost difference between the most economically advantageous plots and the ones either bordering others for the agglomeration bonus or being located in a target area for the threshold bonus.

For an exemplary study area in Germany, we tested the model for the agglomeration bonus in a pilot run, the results of which are presented here. The selection of the farms is organised as follows: First, within the study area shaped as a square of 1000 ha all farms with at least one field are identified. In a second step the farms are ranked following the formula: farm's share of arable fields inside the square * share of square covered by this farm's arable fields. In the tested study area 14 farms have been selected that together farm 606 ha of arable land. The size of the farms varies between 6 and 91 hectares of arable land. Figure 1 shows their spatial distribution. The one-hectare parcels have the shape of a hexagon, so that each parcel has six neighbouring parcels. Depending upon the size and shape of the single field, there are connections to other parcels belonging to the same field, to parcels of arable land managed by other farmers or to parcels that aren't arable land. It becomes visible that arable land use of the selected farms is quite fragmented.

3.3.3 First results

In line with the 4% conditionality rule in total 24,24 ha have to be established as habitats. This concerns 31 parcels if each farm is establishing habitats on 4% of its arable land and when including those parcels, that have to be taken out of production only partly and. They are marked with a black outline of the hexagon in Figure 3-8. As expected when the selection is solely based on individual economic parameters without spatial

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coordination or collaboration needs, only few habitat parcels lie near to each other, several ones are highly isolated.

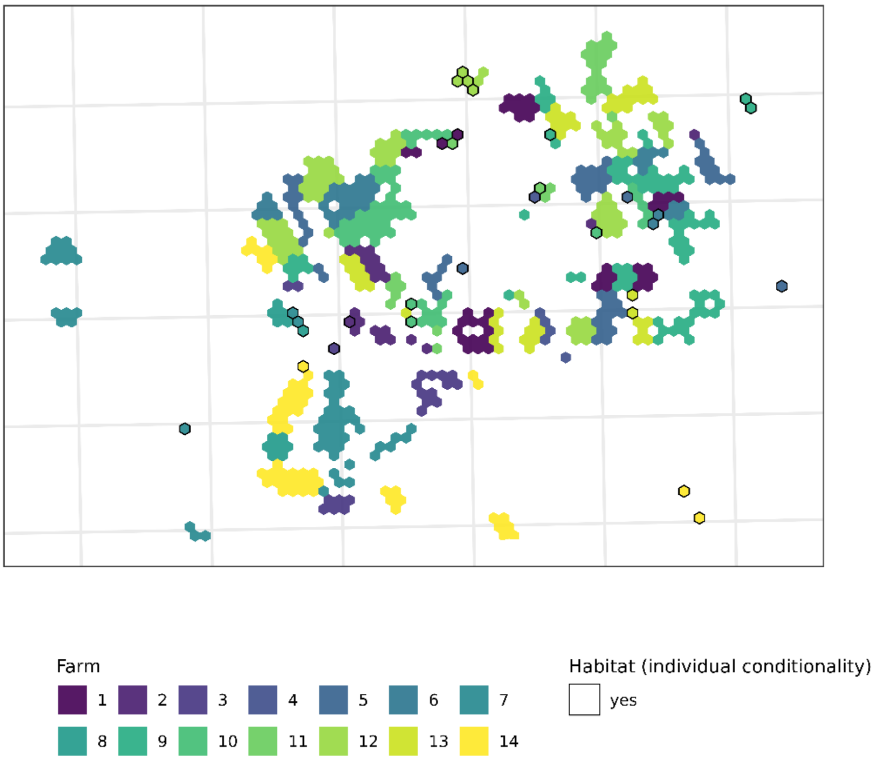

Figure 3-8. Distribution of habitat parcels as established under individual conditionality without spatial coordination/collaboration incentive

For this model run, the gross margins have been calculated for each 1 ha cell using the crop distribution from the 2018 IACS data. The yields are based on regionalised statistics from the 2018 harvest which was a dry year with yields below multi-year averages. Data adapted to the cost structure of the administrative regions across Germany were used for input and machinery (KTBL, 2022).

The distribution of the gross margins across the study area at parcel level is shown in Figure 3-9. The values lie within a range between 184.46 EUR/ha and 2518.54 EUR/ha with an average value of 606.19 EUR/ha across all farms. For the 24.24 ha that become habitat under individual conditionality the gross margin loss equated with the opportunity cost is 8137.52 EUR (on average 335.71 EUR/ha).

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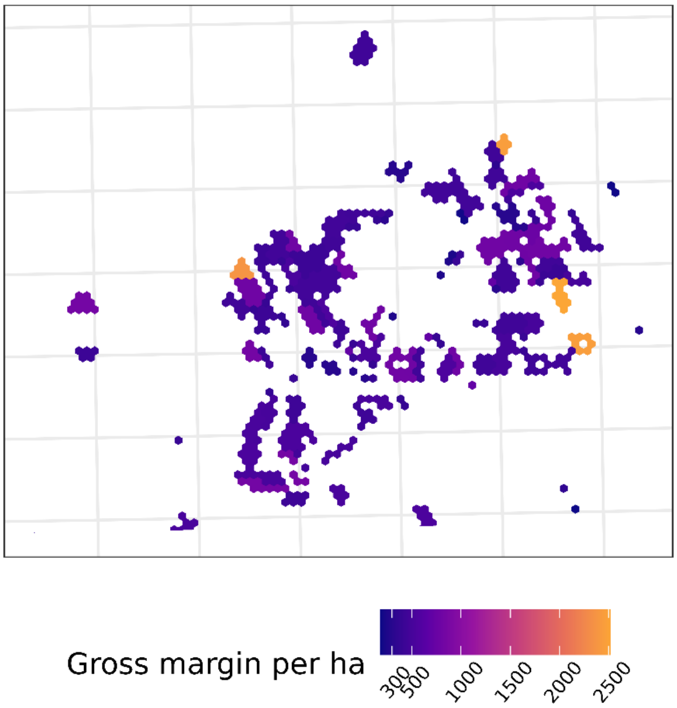

Figure 3-9. Distribution of the gross margins of the arable land within a study area.

In a second step, these 14 farms were divided randomly into two groups. Each of the two groups can engage with additional parcels into the eco-scheme. Within the groups the habitats can be placed where it generates the highest benefits for the group. The eco-scheme payment resulted in 24 additional habitat parcels, ranging from 0 to 5 parcels per farm.

Finally, in order to assess the effect of an agglomeration bonus paid for each connection between habitat parcels, two different payment levels were introduced. With just the staggered eco-scheme payment and no bonus payment the habitat parcels are broadly dispersed and there are by chance 2 connections. With a bonus payment of 50 EUR 19 connections are realised with 25 habitat parcels receiving eco-scheme payments. For a bonus payment of 75 EUR 29 connections are realised and the number of parcels established as habitats under the eco-scheme reaches 29. This shows that with a bonus payment the ecological benefits resulting from connecting the habitats could be considerably increased. Their location is shown in Figure 3-10.

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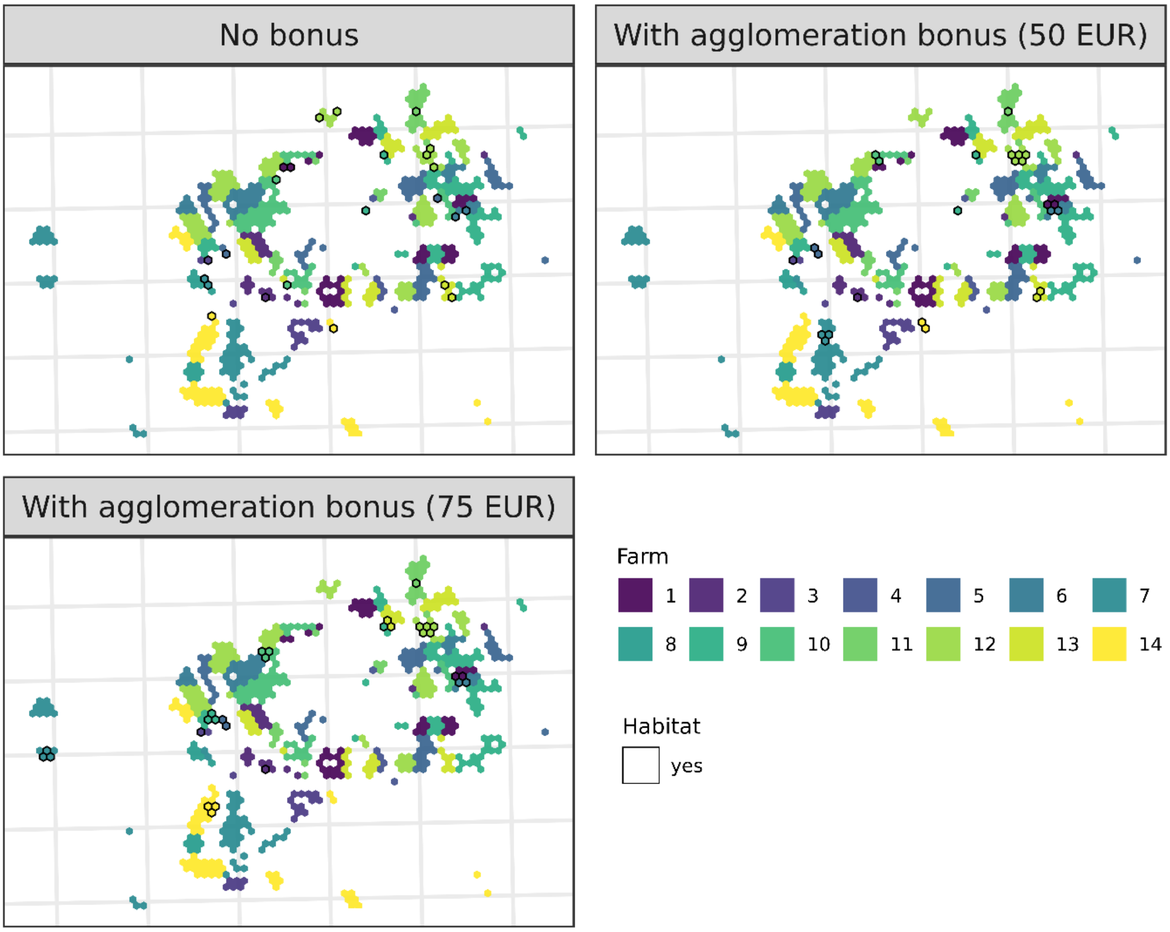

Figure 3-10. Distribution of the habitat parcels established as eco-scheme measure without bonus (staggered eco-scheme payment only) and with two levels of bonus payments on top of the eco-scheme payment

The payment of an agglomeration bonus clearly impacts the advantageousness of the individual parcels to become habitats. In our study area, a bonus payment of 50 EUR brings us to 20 connected habitat parcels out of the 25 NPAs established with eco-scheme payment, with four clusters of habitats composed by 2 ha, one by 3 ha, one by 4 ha and one by 5 ha. This includes one connection between farmland of different farms, even though no payment differentiation has been made between connections of 2 parcels from the same farm or from different farms. With a bonus payment of 75 EUR out of the total of 29 eco-scheme habitat parcels 26 are connected, with four clusters of habitats of 3 ha, one of 4 ha and two of 5 ha. Here, 3 clusters of habitats are formed with parcels from different farms. Thus, the agglomeration bonus has a clear steering function and was able to positively influence the location of habitats not only leading to an increase in the number of connected habitats, but also to larger contiguous habitats.

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Table 3-2 compares the three preliminary model runs, the one without bonus and the ones with an agglomeration bonus of 50 EUR or 75 EUR respectively (see table 1). The total premium in the study area is calculated for both groups together. It is composed by the staggered eco-scheme payment with payments in line with the individual share of land designated as habitat per farm and when relevant the bonus per connected habitat parcel. Without bonus, the eco-scheme payment sums up to 14 244 EUR. This compares with opportunity costs amounting to 8 501 EUR, resulting in a profit of 5 744 EUR for the 14 farms. The average profit is 239 EUR / ha of habitat. For the 20 connected habitat parcels achieved with the 50 EUR bonus the total premium is 15 269 EUR, including 950 EUR for the agglomeration bonus. With the opportunity cost arising now to 9 150 EUR, the average profit is 245 EUR / ha of habitat. Finally, for the 26 connected habitats achieved with the 75 EUR bonus the total premium is 19 179 EUR and the average profit is 269 EUR/ha. It could be shown that the bonus enabled the farmers' groups to introduce some additional habitats and – more relevant – to relocate others. The economic best solution for the groups, is not necessarily the best for the single farmer. While the plots bringing the highest benefit at group level are the ones selected as habitats, it requires a fair distribution of the premium amongst participating farmers.

Table 3-2. Overview table without and with agglomeration bonus

	No bonus	Agglomeration bonus (50EUR)	Agglomeration bonus (75EUR)
Habitat parcels	24	25	29
thereof with connections	(2)	20	26
Number of connections	(2)	19	29
Total premium	14 244	15 269	19 179
thereof bonus payment	0	950	2 175
Total opportunity cost	8 501	9 150	11 385
Total profit from participation	5 744	6 119	7 794
Average opportunity cost per ha	354	366	393
average profit per ha habitat	239	245	269

3.3.4 Conclusions

With the simulation of the agglomeration bonus payments we get a better understanding on how to steer collaboration for the placing of NPA in the landscape in such a way that it is beneficial for biodiversity protection.

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In the first modelling exercise, we focused exclusively on the habitat plots receiving eco-scheme payments. The habitats resulting from the conditionality were fixed in their number and spatially and not included for a possible re-location. Furthermore, we randomly established two groups of seven farmers and did not yet allow farmers to move between the groups. With the help of our exemplary model run it was possible to demonstrate that collaboration of farmers can be incentivised by an agglomeration bonus in order to increase the number and size of contiguous habitats. It could be shown that already a moderate agglomeration bonus of 50 or 75 EUR/ha leads to considerable improvements in the spatial setting of habitat area.

We expect our future results being of great relevance for the future design of agri-environmental measures that can be designed as a top-up to the conditionality and the eco-scheme measure NPA to increase the ecological value of these sites by connecting habitats. However, besides the placement of habitats additional aspects to further increase ecological effects could be incorporated. As one example, adding the obligation to leave the fallows untouched during winter brings considerable benefits for our model species grey partridge, but also insects and other bird species during winter (Šálek et al., 2022).

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3.4 Modelling result based and collective contracts through the use of a Multisided platform (MSP) (CO_UNIFE_UNIPI_TI)

3.4.1 Introduction

When switching to the implementation of a landscape-scale and result based approach for Agri-Environmental Commitments (AECs), public and private transaction costs (TCs) play as major constraints (Batáry et al. 2015). Public TCs underly the acquisition of information on the spatial configuration of heterogeneous opportunity costs and environmental values (i.e. the control over the designated areas), the calibration of the incentive mechanism (i.e. the effectiveness of payments, side payments and budget adequacy), and the monitoring of results rather than expenditure. Public TCs are also related to the greater organizational and management capacity that is needed for the preliminary work on the animation of the territory, on the creation of local leadership and on the effective involvement of intermediate levels of territorial governance (Chiodo and Vanni, 2014). In addition, local government agencies often work understaffed and with limited budgets or high spending constraints, which does not facilitate the development of complex management tools. High private transaction costs required for coordination can also explain farmers resistance to take part in collective schemes (Rolfe et al., 2022; Coggan et al., 2013), or alternatively motivate farmers to offer only cheap parcels, which might not be the best to enable spatial coordination across the landscape (Nguyen et al., 2022).

A potential solution to these major drawbacks is offered by the current digitalisation process and the new digital ecosystems (Barykin et al., 2020). There is a growing discussion on how the current digitalisation process and related disruptive "4.0" technologies can assist the agricultural sector in advancing an ecological transition (Klerkx et al., 2019). However, most contributions focus on farm-scale solutions applicable by farmers through commercial innovative business models. Little has been said about how new technologies could also shape the public sector, and could be integrated as innovative policy tools. Smart digital tools including aerial imagery, robotics, machine learning, cloud computing, automation, drones, GPS, and smart sensors (Zysman & Kenney, 2018), Multisided Platforms (MSPs) are attracting considerable research attention due to their ability of triggering specific positive effects on the economic, organisational, institutional, and spatial structures in which they are embedded, and their use is rapidly growing (Bonina, 2021). Although there are multiple definitions

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of MSPs depending on the specific tasks that they allow users to perform and somewhat on the field in which they are analysed, the interest in the current work is on their intermediation and integration characteristics and on their impact on governance and organisational structures. MSPs are digital services that enable direct interactions between two or more groups of agents (Rochet and Tirole, 2003; Armstrong 2006). The brokerage model behind MSPs (Rochet and Tirole, 2006; Gawer and Cusamano, 2002) could facilitates transaction between multiple sides of a market (e.g. the public administration as a buyer and farmers as a seller) while benefitting from networks effects that make them powerful 'transaction platforms' as proved by Cusumano et al. (2019). As modular architectures could also offer a unique environment for using data generated during the design and implementation phase of result-based and collective approaches for AESs. For example, developers (complementors) could develop apps for simulation, monitoring, for the development of new indicators and standards which in turn would benefit the user decision-making, making more accessible the development of innovative capabilities (Gawer, 2014). As far as performance measurement is concerned, this could lead to significant progress towards lower public spending on monitoring results, thus maintaining future CAP budget for farming. Finally, MSPs allow users to perform a different set of tasks within architectural and governance structures that are different from other types of market settings (Evans & Schmalensee, 2016). From this perspective, which is close to that of information systems (ISs), MSPs could have a huge impact on the organisational structures operating within current AESs regime (de Reuver et al., 2018). Typically, AES are centralised by regional governments in an agency relationship with farmers. The possibility of switching to the landscape level implies hybrid forms of governance and MSPs can be relatively open and shared while maintaining a centralised control (Hanseth & Lyytinen, 2016).

Despite MSPs bringing distinct characteristics that could have unique implications for the design and implementation of result-based and landscape-level coordinated implementation of AES, there are no current application for this purpose.

Against this background the analysis aims to explain what do MSPs mean for the design and implementation of AECs at landscape scale accounting explicitly for TCs (public and private) (Nantongo & Vatn, 2019; Henten & Windekilde, 2016; Coggan, et al., 2013), network size and externalities (Rochet and Tirole, 2003, 2006; Armstrong, 2006). Building on two-sided markets literature (Weyl, 2008; Armstrong 2006; Rochet

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and Tirole, 2003;) and spatially explicit competitive mechanisms (Fooks et al., 2006) we set up a theoretical approach for a quasi-market MSP for result-based and collective AECs. The exercise allows us to illustrate key aspect for securing the coordinated implementation of environmental contracts, i.e. namely: searching, transacting and monitoring costs, as well as more effective and targeted matching between demand and supply, and discuss implication for social welfare and policy design.

3.4.2 Model description

3.4.2.1 Background information

In CONSOLE we refer to contractual mechanisms for the transaction of environmental goods and services between the farmer (seller), and society, represented generally by a public authority, i.e. the Region (buyer). TCs are the costs arising from organising the transfer of goods and services between sellers and buyers.

In a hypothetical market for AECs, these costs are related to search, decision-making, negotiation, monitoring and enforcement, and coordination activities. Within our modelling framework, these costs represent the sector's spare capacity. According with Jacobides et al., (2019) the greater is such spare capacity, the more compelling are the efficiency gains from developing an external market in that capacity. Transaction costs as a spare capacity is not new to the MSPs literature (Henten and Windekilde, 2016). Successful MSPs “create enormous value by reducing search costs or transaction costs (or both) for participants” (Hagiu, 2015). These entities develop precisely by virtue of their ability to absorb these costs and turn them into profits (e.g. uber, airbnb), so from an economic point of view it makes huge sense to use it rather than leave it sit idle. The problem for the decision maker become how to turn TCs related to AECs in a value for farmers toward greater efficiency and results, which are also major priorities within the new CAP framework.

According to Mettepenningen et al., (2011), for a Public Agency organising the AEC contract, the total costs is composed of Public TCs: administrative costs plus compensation payments including private TCs; and Private TCs2 (born by farmers):

[2] Search and decision-making costs (ex-ante costs, include the costs for looking for information on AESs, compare the AES-option with other alternatives etc. Furthermore, choosing one or more AES from a whole menu and choose the field(s) on which to apply them, or compare the compensation payment to the expected costs arising from AES-uptake, the cost of making the wrong decision); Negotiation costs (application costs and cover the costs of fulfilling preliminary conditions to be able to apply, specific administrative tasks, following specific training, drawing field maps or taking soil samples, as well of the administrative costs of applying, the costs of contacting the Administration when there is problem with the application; Monitoring and enforcement costs (ex post and includes costs the farmer incurs as a result of monitoring and enforcement activities, e.g. the farmer can be obliging to keep fertilisation records, to accompany

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search and decision-making costs, negotiation costs, monitoring and enforcement costs, coordination. On top, we have uncertainty cost (i.e. cost related to the uncertainty delivered by the type of mechanism considered like result-based or collective)

But what type of TCs could the platform turn into value? and which activities do they correspond to? In Figure 3-11 we provide a basic analytical representation of these costs in relation to the platform domain activities.

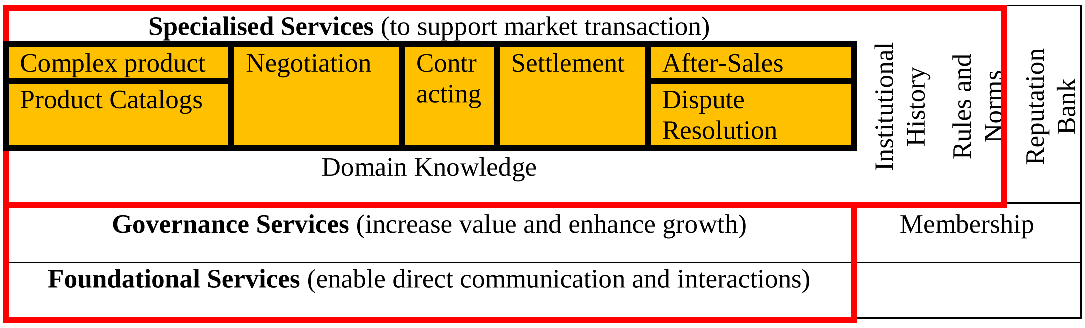

Figure 3-11 Platform and TCs (red public TCs, orange private TCs)

The platform activities can be grouped in three main levels of services. To the first domain corresponds all those specialized services that can enable transaction, improve matching between demand and supply, facilitate decision-making (e.g. through the use of maps allowing better decisions on which fields to apply, or to select) and thus contribute to reduce both public and private TCs. At the next levels we find more general services that belong to the governance and foundational domains. These services differ in function of the type of platform we consider. We assume a public platform like the recently developed EU FaST platform (https://fastplatform.eu/). Accordingly, the benefit generated by these services are related to the reduction of public TCs.

Among specialised and governance services we identify five potential type of services and their main contribution in reducing both private and public TCs (Table 3-3).

Table 3-3. Platform services and expected impact on private and public TCs

Specialised & Gov. services	Reducing private TCs	Reducing public TCs
Maps overlaying farm data on GIS layers + simulation of modelled results	Visualize and analyse spatial information provide single environment for: - product optimisation - resources efficiency Facilitate decision-making	Facilitate contract design, evaluation and monitoring - allow the analysis of spatial pattern configurations - provide simulation of "Buyer Environmental Benefit Value"
Search and matching	Show available tenders Allow quick cross-comparision of contract	Increase selection effectiveness

the control agency to his fields when soil samples need to be taken, to count birds' nests or to do other administrative tasks in order to prove he has performed his contractual obligations)

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	options, including simulation of expected participation costs	
Negotiation costs	On-board farmers are ready to participate	Automatic administrative controls by providing an Administration Portal where for example the Paying Agency can access the regional data, configuration and user profiles Constant global monitoring on applications Online training services and two-way communications
Monitoring and enforcement	Live management of records and information: constantly updated, organised and transferred	The public agency has summary information and result indicators calculated automatically and constantly available in the administration portal

For farmers, the platform allows:

- to improve agronomic performance while reducing input and other production costs and environmental impact;
- facilitate decision-making when participating in AEC;
- provide information on available contracts;
- allow for quick cross-comparison, compare the contract-option with other alternatives including simulation of expected participation costs form alternatives.

While for the public agency:

- improve the design of the spatial targeting mechanism and related evaluation and monitoring activities (register compliance with AECs, GAECs, etc.);
- reduce adverse selection in selecting participant and compare potential spatial pattern configurations (agglomeration vs scattered solutions);
- provide a simulation of calculated "Buyer Environmental Benefit Value" based on spatial optimisation of applications;
- allow two-way communications;
- allow for economies of scale in the management of AEC.

3.4.2.2 General assumptions

We assume that given a budget (B), the public agency launches the platform through a pilot tender for AEC contracts in a specific territory with a targeted population of farmers N_S, the so called "design phase" (prototype and launch).

A key feature of most MSPs is that the value to one side typically increases with the number of participating users on another side (i.e the so called cross-side network effects or indirect network effects). This aspect however entails an inherent chicken-and-

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egg problem for the platform maturity phase: no side will join without the other or others. Overcoming the chicken-and-egg problem is one of the major barriers for the development of MSPs. Weyl and White (2014) suggest that by adopting temporary subsidization strategies there is "*no reason to worry that the program will fail to live up to its intended level of popularity. In other words, this means that, by using such strategies, the public authority can achieve whatever participation level it desires*", and without concern for users' mis-coordination.

Assuming a positive growth rate of the platform by the process of building critical mass we find the second step the so called "ignition phase" where frictions and bottlenecks are removed. Then assuming a net positive increasing rate during years we find the "maturity phase" where most of the strategies aim at retain existing network and connect to others.

These phases generally take a long time, probably in the context of AECs it would take several programming cycles (at least 3), where in the most optimistic scenarios we can assume that the farmers' side (N_s) would grow.

Differently from previous literature on two-sided markets, here we consider the public regulator as unique buyer that open different tenders to buy AECs from farmers. Accordingly, demand is approximated at the beginning of a programming period by the expected maximum number of applications that can be potentially cleared N_b with the available budget B for each tender considering an average participation cost of all farmers in the same area in each programming period. This mechanism restricts the participation to those farmers whose compliance costs are below the average marginal payment (underestimation). To refine the estimate, we can assume that at the end of the programming period, the target applications will be corrected with a measure of the realised participation.

3.4.2.3 Conceptualisation of platform

We assume a multi-stage decision making problem that employ a multi-attribute reverse auction that allow for spatial targeting and network bonus for individual decisions (Bingha and Borges, 2021; Vergamini et al., 2020; Banerjee et al., 2015; Fooks et al, 2006) and a two-sided market model for the maximisation of the social welfare produced by the platform (Armstrong, 2006; Rochet and Tirole, 2003). The multi-stage decision-making is summarized in Figure 3-12

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Stage 1	Individual decision making	Bid formulations and bid selection	Reverse auction model
Stage 2	Social welfare maximisation	Analysis of per-interaction prices (membership fees, TCs), and volume of trade	Two-sided market model

Figure 3-12. Schematic depiction of the multi-stage decision-making.

While for the purposes of this report we focus on Stage 2, for the ease of reading we refer the theoretical development of Stage 1 to the cited contributions. We can overlook Stage 1 as it represents only the allocation mechanism of the transaction, which we can consider consolidated knowledge, efficient and capable of promoting spatial coordination (Nguyen et al., 2022). In addition, there are two key aspects to emphasize. The first concerns the technologies used by the platform. Assuming that these can improve the capabilities of individuals to form opinions on the distribution of benefit and costs (direct and opportunity) in delivering spatially coordinated environmental outcomes, we know that it also improves the efficiency of the auction mechanism (Lockie, 2013). Second, the platform model exhibits economies of scale (Hagiu, 2015). The advantage of developing multiple tenders in a single digital environment or market is linked: a) to the opportunity of reducing TCs and increasing the outcomes produced, and b) to the value of the generated transactions and of their higher control.

Accordingly, in the second stage we analyse the effect of a growing two-sided market model, and thus discuss the effect of network externalities and its implication for TCs on the effectiveness of the outcomes produced.

The platform can be modelled as a particular market setting where two groups of agents interact via the platform as an intermediary. In this market surplus is created (note that the surplus can also be destroyed in case of negative externalities) by interaction. Assuming positive cross-group externalities, the benefit enjoyed by launching a tender depends upon how well the platform does in attracting farmers on the other group. And this clearly depends on the balance between benefit generated and costs for operating the services and implementing transaction, so the platform price structure3. In other words, since each farmer can exert large positive externality on each tender, farmers represent

[3] According to the literature, when designing the price structure the platform should find a balance between sides' sensitivities for prices and competition with other platforms. For the first aspect the cross-group externalities are weaker with per-transaction charges, while for the second the difference between the two forms of charges is crucial only when there are competing platforms

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the main target of the platform. On this side the platform might charge for its services on a lump-sum basis, or decide to link the charge to the platform's performances. This choice clearly depends on the benefits offered to farmers, so first of all on the possibility of reducing private TCs to access the tenders compared to the current costs of participating in the RDP measures. Assuming a fixed tariff to be onboard, as in the monopoly platform case (Armstrong, 2006), the farmer's incentive to join the platform does not depend on the platform's performance on the other side, and he/she will join if and only the usage benefit is greater than the participating costs.

Considering N_s and N_b members of the two groups, the utility of the farmers is $u_s = \alpha_s N_b - p_s$, where α_s is the usage benefit and p_s is the fixed fee payed by the farmer to be onboard. At the same time the utility for the public regulator of clearing one application is $u_b = \alpha_b N_s - p_b$, where α_b is the benefit obtained from an application and p_b the related cost.

Since we are dealing with a public platform as in the case of the EU FaST platform, p_b is not a traditional fee like in many other examples of private platforms (Armstrong, 2006) but in this specific case it mostly represents a public transaction cost component associated with the transaction TC_{pub}. Thus $u_b = \alpha_b N_s - \mathrm{TC}_{pub}$.

The usage benefit for the farmer are clearly based on the outcomes he/she will provide in Stage 1 through the AEC to whom is attached a result based payment b and a network bonus γ. Since we consider spatial explicit benefit for the regulator the objective is to maximise certain environmental outcomes Δe (e.g., the increasing in the reduction of soil erosion) within a given configuration of land parcels X from the total area eligible to participate in the tender. The buyer selection through the platform tools will maximise the function G1 that represents the optimal configuration of spatial outcomes. From this optimal configuration the buyer derives a benefit that we measure in a simplified way as $\alpha_b = (\tau G_1)$, where τ can be a monetary coefficient that expresses the marginal value of a certain parcels' configuration.

Following Armstrong (2006) we can further specify the number who participate as a function of the utilities (demand model): $N_s = \phi_s(\mathrm{u}_s), N_b = \phi_b(\mathrm{u}_b)$ for some increasing function $\phi_s(\cdot)$, $\phi_b(\cdot)$[4].

[4] According to Armstrong (2006) we can employ a quadratic form $\phi(\mathrm{u}_s) = a_s + b_s u_s + c_s u_s^2$; $\phi(\mathrm{u}_b) = a_b + b_b u_b + c_b u_b^2$

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Then with regard to the costs, we suppose the platform incurs a per-user cost cv_s, cv_b for serving group (1,2) that we can group among public TC_{pub} and private TC_{priv} as following:

$$TC_{tot} = TC_{pub} + TC_{priv}$$

$$TC_{pub} = f_b + cv_b = f_b + cv_b N_s,$$

Where the per-transaction cost is related to the actual size of the farmer network, and for cv_b quite small (i.e. <0.5) the variable cost is degressive which means that as the network size increases thanks to economies of scale in the management of transactions, the cost should increase but less than proportionally.

$TC_{priv} = f_s + cv_s = f_s + cv_s N_b$, we assume the same applies for the cost of serving farmers, as more application can be potentially cleared with a certain level of budget this cost should be reduced. In this way we aim to capture the effect of the network size on the per-agent costs. When the platform deal with a large network we expect through economy of scale that this cost will be reasonably lower than when it works with small groups.

Against this background, the public's decision-making problem in a two-sided market configuration that integrate a principal-agent problem with an intermediary is to maximise the social welfare function (Z) measured by the unweighted sum of the value generated for the public decision maker and farmer surplus $v_s(u_s)$[5] as follows:

$$Max\ Z = N_b\left(\tau G_1 N_s - TC_{pub}\right) + N_s(p_s - TC_{priv}) + v_s(u_s) \quad (1)$$

That in terms of utility (not prices) becomes: $p_s = \alpha_s N_b - u_s$

$$Max\ Z = \phi_b(u_b)[\tau G_1 \phi_s(u_s) - TC_{pub}] + \phi_s(u_s)[\alpha_s \phi_b(u_b) - u_s - TC_{priv}] + v_s(u_s) \quad (2)$$

From the first order condition the farmer utility that maximize the outcome produced is:

$$u_s = (\alpha_s + \tau G_1)N_b - TC_{priv} \quad (3)$$

Given the benefits, the great impact here is determined by parameters exogenous to the farmer decision-making, namely the size of the other group that join the platform and the ability of the platform to reduce private transaction costs. The larger is the network, the lower should be the impact of TCs and therefore the benefit of being onboard is greater.

[5] $v_s(\cdot)$ satisfies the envelope condition $v'_s(u_s) \equiv \phi_s(u_s)$;

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From expression $u_s = \alpha_s N_b - p_s$ then we can derive the socially optimal prices as:

$$p_s = TC_{priv} - \tau G_1 N_b = f_s + cv_s N_b - \tau G_1 N_b = f_s + N_b(cv_s - \tau G_1) \quad (4)$$

The optimal price for farmers equals the cost of providing the service adjusted downwards according to the benefits they bring to the platform. Clearly this depends on the platform development stage (design, ignition, maturity). In the early stages we can deduct high transaction costs and few users and therefore a lower benefit and consequently a higher price. In this case, the optimal strategy may not coincide with the result of the model where it is decided, for example, to bear part of the farmer's costs as an incentive to adopt and build a strong network (i.e. access could be free for farmers). After that, as more users are added, the public incentive could be reduced until the maturity stage is reached (Dybvig and Spatt, 1983). Then, considering just the two first components of expression (2) in a similar fashion of Armstrong (2006) the profit-maximizing prices should satisfy:

$$p_s = TC_{priv} - \tau G_1 N_b + \frac{\phi_s(u_s)}{\phi'_s(u_s)} \quad (5)$$

Where a factor related to the elasticity of the group's participation should be considered in adjusting upward the price. However, it is also possible that the welfare-maximizing outcome involving farmers is continued of being offered through a subsidized service, i.e. $p_s \leq TC_{priv}$.

This result generally occurs if the group's elasticity of demand is high and/or the external benefit enjoyed by group 2 is large. Indeed, the subsidy might be so large that the price is zero or even negative (when an extra incentive is given for using the platform).

3.4.3 Discussion

The analysis focuses on transaction costs as a main obstacle for the development of collective and result-based contracts. We developed a theoretical framework to set out a MSP for the provision of public goods at landscape-scale in which both private and public TCs are taken into consideration to evaluate the platform performance and analyse its main structural (design) and market strategies. The modelling stage describes how and under which conditions the MSP can represent a (theoretically) viable situation to improve the effectiveness of the provision of public good by coordinated actors and how competitive tools should be used in order to achieve such coordination.

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Technology clearly affects TCs under the three main platform domains: Knowledge, Governance and Foundational (Figure 1). Within these domains, technologies can have a positive impact on users' utilities and on the platform performance when allow for modularity, interoperability, and are designed to be cloud-based, open-source and user-friendly.

Our contribution remains theoretical as implementation process is the most crucial phases for the platform and for the effective development of a network effect. For example, overcoming chicken-eggs problem mentioned in the theoretical part is a strong hindering factors and other implementation parameters (i.e. in terms of value proposition, governance, accessibility, communication, price, switching costs) require further analysis.

In our design, the platform assumes the role of a public intermediary, thus an intermediate role in the typical principal-agent relationship for AECs between the Region and farmers. The feasibility of this position is concrete given the recent development of the public FaST platform at European level which is proposed by the EU Commission as an intermediary between EU farmers, Member State Paying Agencies, farm advisors and developers of digital solutions for sustainable farm and land management. Clearly this shift in the governance of AECs strongly depends on the characteristics of modularity, interoperability and open-sourcing level of the platform design, but also on the guarantees of transparency, security and privacy in transactions. As an intermediary we have shown how it ensures a reduction in both private and public transaction costs and this could represent an advance for the effective implementation of landscape-level and result-based approaches.

However, considering the evolving digital ecosystem and a growing interest for the establishment of private platforms, further studies need to analyse the coherence between private platforms and the AECs governance, as a crucial factor for its success, as competition in provision of public goods or as regards different level of payments for service provided are relevant parameters.

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4 Discussion and Conclusion

The models developed within task 4.4 provide a comprehensive overview on different aspects related to the modelling, the design, and the assessment of collective approaches. All the model focus on biodiversity conservation. This is an area of policy interventions for which collective approaches have been for long advocated (Lefebvre et al., 2015).

Three of the models address the design of the so-called agglomeration bonus. Such a scheme is a specific, spatially explicit, collective approach that incentivizes the connectivity between habitats. The three models target the key issues that are at the core of the task (Table 4-1). CO_UNIBO_1 tests whether different assumptions on the cooperative behaviour of farmers matter for the assessment of collective approaches, and in particular, of the agglomeration bonus. Building upon CO_UNIBO_1, the exercise CO_UNIBO_2 analyses different design options of collective approaches, varying on two contract parameters. While the previously described exercises are highly theoretical in nature, CO_TI_UNIBO is one of the few examples where the agglomeration bonus is tested on a real landscape and within an actual policy (the CAP). Finally, CO_UNIFE_UNIPI_TI addresses the problem of how bridging institutions can lower transaction costs linked to cooperation to implement collective approaches.

Table 4-1 Main results from the model exercises of task 4.4

Model	Issues analysed	Main results
CO_UNIBO_1	Evaluation of modelling assumptions on the farmers response to an agglomeration bonus	Assuming a cooperative behaviour among farmers would lead to an overestimation of the effectiveness of an agglomeration bonus
CO_UNIBO_2	Assessment of agglomeration bonus design options	Setting a project design, rather than ambient, seems the most effective design for the agglomeration bonus
CO_TI_UNIBO	Assessment of agglomeration bonus in a real landscape	Cooperation among farms is rather limited, but adding agglomeration bonus to the current design of eco-scheme could highly improve the connectivity of the landscapes with little extra expenditures
CO_UNIFE_UNIPI_TI	Assessment of coordination platforms	By reducing the transaction costs related to coordination, platforms could improve the

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The main messages and insights from the modelling exercises are reported in Table 4-2. The results of the models generally suggest that collective approaches can indeed provide greater effectiveness than the traditional individual agri-environmental measures. More importantly, the methodological developments carried out in the tasks provide a framework to better tailor the assessment of collective approaches and indicate the conditions under which collective approaches are more performative than traditional agri-environmental schemes. For example, CO_UNIBO_1 suggests that indeed modelling assumptions matter for the assessment of the agglomeration bonus. In case the individual decision on cooperation is taken into account, the agglomeration bonus is more effective than traditional agri-environmental schemes especially at low level of public expenditures. In such a case, the few plots of land that are conserved are more clustered and hereby generate more biodiversity than individually-targeting agri-environmental schemes. CO_UNIBO_2 shows that also the design of the scheme matters. Comparing different reward settings, the results indicate that designing an agglomeration bonus scheme that is based on project formulation is the most performative option. CO_TI_UNIBO suggests that the main theoretical results hold even on real landscapes, where e.g. farm sizes are irregular and ownership is scattered around the landscape. Indeed, the agglomeration bonus is able to cluster conservation efforts and provide habitats characterized by greater connectivity. Finally, CO_UNIFE_UNIPI_TI shows that the creation of bridging institutions can help lower transaction costs linked to the coordinating activities, and hence increase the effectiveness of collective approaches. The models also show that the relative ranking of agglomeration bonus schemes and traditional agri-environmental schemes depends on the dimension taken into account for the evaluation. Irrespectively on its design, the agglomeration bonus results in a similar habitat area as homogenous payments, but with a selection of plots that are characterized by higher opportunity costs on average and that creates higher connectivity among habitats. At the same time, higher biodiversity levels are reached per level of public *expenditures*.

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Table 4-2 Main messages from the model exercises of Task 4.4

Task objectives	Main messages
1) How collective implementation might emerge in different contexts	Explicit consideration of mechanisms leading to cooperation is needed. Assuming a cooperative behaviour among farmers would lead to an overestimation of the effectiveness of an agglomeration bonus scheme.
2) How collective contracts are facilitated by public policies	Direct incentives in the form of AB stimulate agglomeration. Platforms or other supports to coordination could improve the effectiveness of collective approaches, by reducing the transaction costs related to coordination. The effect of AB is more important for low expenditure level. The relative effectiveness of the AB with respect to traditional agri-environmental schemes depends on the landscape dimension

The limitation of the modelling exercises provides the ground for future research. Moving from a theoretical perspective (see e.g. CO_UNIBO_1 and UNIBO_2) toward more empirically based model simulations (e.g. CO_TI_UNIBO) requires substantial efforts in terms of conceptualization and implementation. Further efforts in this direction seems crucial and demand for fine-granulated data on different aspects. CO_TI_UNIBO has been possible only due to the availability of spatially explicit data on both land use and land property. Moreover, to empirically substantiate the modelling of collective approaches, behavioural parameters and perspectives seem crucial. A large literature has shown through experiments that cooperation and coordination is highly affected by a range of behavioural parameters that should hence be included in any model. Having robust estimate of the attitude toward cooperation from individual farmers would enable to improve the modelling exercises that include the assessment for the agglomeration bonus and of bridging institutions that help collaborating.

Also, from a theoretical point of view, there seem to be the need of further advancements. All the models here presented are solved empirically due to the difficulty of analytically solving spatially explicit (and hence, binary) decisions. While the problem asks for spatially explicit treatment, such an approach suffers the lack of generalizability. Further efforts are needed to develop theoretical models that, even though abstract away from spatially explicitly issues, are capable to provide insights in the design of collective approaches.

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6 Acknowledgment

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement GA 817949