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Spatial Coordination Incentives for landscape-scale environmental management: A systematic review

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ABSTRACT

Conventional agri-environmental schemes (AES) have been criticized for failing to exploit conservation synergies that could be obtained from spatial coordination of conservation efforts. Understanding the design and implementation of novel incentive mechanisms explicitly designed to boost spatial coordination of conservation efforts is, therefore, of critical importance. We conducted the first systematic review of such incentives ('Spatial Coordination Incentives'), including Agglomeration Bonus, Threshold Bonus, and Threshold Payments. The review aims to investigate these incentives' performance and identify the underlying factors affecting their performance. An extensive bibliographic search was carried out and 55 papers were included in the final analysis. Most papers (89%) are theoretical and experimental studies. Real-world applications of these incentives are rare. The theoretical and empirical evidence suggests that these incentives could potentially promote participation, spatial coordination, and environmental effectiveness. However, the results remain a subject of debate in experimental studies. Performance variation is attributed to scheme design features and contextual factors. We highlight the areas where future work would be most warranted to further validate the performance of these incentives. Insights gained from the review provide important implications for the emerging field of conservation science and ongoing efforts to improve the design of AES for better landscape-scale management.

1. Introduction

Over the last decades, agri-environmental schemes (AES) have been implemented worldwide as a collection of policies including market-based instruments to tackle a wide range of environmental problems linked to the management of farmland. Such problems include biodiversity loss, water pollution, and land degradation. Many governments across the world have allocated large budgets to fund AES, in order to remunerate private landholders for the provision of (largely public) ecosystem services (Salzman et al., 2018). For instance, the European Union spends about €2.5 billion per annum on AES (Westerink et al., 2017). However, the environmental and ecological effectiveness of AES has remained modest (Arnott et al., 2019; Berendse et al., 2004; Samii et al., 2014). While AES have proven to be effective at delivering environmental outcomes in some locations, they have largely been ineffective in achieving landscape-level outcomes (Bos et al., 2017; Kleijn et al., 2006a, 2006b, 2004; Pe'er et al., 2014).

This is mainly because the designs of conventional AES have not considered the landscape as a unit for conservation interventions in the first place. Instead, AES have been designed as incentives for individual actions, targeting environmental outcomes at the farm level (Rotchés-Ribalta and Ó hUallacháin, 2018). Due to their design, conventional AES neither require nor promote landscape-level coordination of conservation efforts across landholders (Goldman et al., 2007). Landholders normally work in isolation to mitigate environmental degradation (such as soil erosion) or to deliver environmental improvements (such as enhancing wildlife habitats). As a result, although AES can trigger positive conservation actions by landholders, these actions are often scattered and disconnected across the landscape (Forman and Collinge, 1996; Leventon et al., 2017).

However, many ecosystem services (e.g. water quality improvements, landscape restoration, and migratory bird conservation) are only achievable at the larger landscape scale that goes beyond the farm scale which conventional AES target (Prager et al., 2012; Toderi et al., 2017;

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Uetake, 2013). The absence of spatial coordination of conservation efforts results in mismatches between the spatial scale of environmental management and that of ecological processes, leading to failures in realising the full potential of AES for environmental conservation (Haaren and Bathke, 2008; Latacz-Lohmann and Hodge, 2003; Rotchés-Ribalta and Ó hUallacháin, 2018). Where spatial dependence of environmental benefits matters for the supply of ecosystem services, the lack of spatial coordination of conservation efforts can lead to a failure to achieve environmental targets such as the restoration of wildlife meta-populations (Goldman et al., 2007; Hartig and Drechsler, 2009; Kuhfuss et al., 2019; Manning et al., 2018; Polasky et al., 2014). This problem has been acknowledged to be a major source of AES ineffectiveness (Emery and Franks, 2012; Falco et al., 2021; Huber et al., 2021; Kleijn et al., 2006a, 2006b).

The switch from a farm-scale and fragmented conservation approach to a landscape-scale approach has been argued to be a step-change that is needed for AES to meet their environmental goals more effectively (Franks and Emery, 2013; Westerink et al., 2017). A landscape-scale approach aims to achieve larger conserved patches, enhanced spatial connectivity among conserved farmlands, and improved habitat quality within the wider landscape (Donaldson et al., 2017).

Collaboration at landscape scales and spatial coordination of neighbouring landholders are considered fundamental components of delivering a landscape-scale approach. Collaboration requires landholders to work together or to undertake collective work to achieve common environmental goals, whereas coordination requires landholders to work towards the same environmental goal but in isolation (Boulton et al., 2013). Both collaboration and coordination of landholders are expected to result in ecological/environmental benefits from spatially connected conservation (Westerink et al., 2017).

On one hand, a growing number of studies suggest that the introduction of collective contracts, such as the new Dutch agri-environment climate scheme, can strengthen collaboration among landholders, thereby boosting spatial coordination at the landscape scale (Barghusen et al., 2021). On the other hand, an emerging set of studies highlights the need to re-visit the design and implementation of individual AES contracting to enhance spatial coordination (Banerjee, 2017a, 2017b, 2017c ; Banerjee et al., 2009; Kuhfuss et al., 2019).

The latter calls for a greater focus on how individual AES contracts should be re-designed to boost spatial coordination of conservation efforts among landholders (Kuhfuss et al., 2019). The quest for Spatial Coordination Incentives that can target spatially explicit landscape-scale ecological benefits is thus of importance for improving AES effectiveness.

Many reviews of AES have focused on the strengths and weaknesses of scheme design (e.g. Wunder et al., 2020), the evaluation of AES performance (e.g. Ansell et al., 2016 and Arnott et al., 2019), and factors affecting AES uptake or participation (e.g. Jones et al., 2020 and Kemink et al., 2020). To date, however, there is no systematic review of incentive mechanisms that are explicitly designed to boost spatial coordination of conservation efforts. Albers et al. (2008) and Drechsler (2020) are among the few attempts reviewing policy instruments for mitigating habitat fragmentation. They have briefly discussed the Agglomeration Bonus, Threshold Bonus, and Threshold Payment as potential Spatial Coordination Incentives to address the problem of habitat fragmentation. However, none of these existing studies adopted a systematic review approach following Snyder (2019), which requires the definition of the specific review questions and a strict search strategy. Therefore, a systematic understanding of the design and the performance of these Spatial Coordination Incentives in both theory and practice is still lacking.

Building on this background, we have conducted the first comprehensive and systematic review of the literature on spatial coordination incentives, including the Agglomeration Bonus, Threshold Bonus, and Threshold Payments, from the perspective of both theory and practice. The review aims to improve our understanding of the design and implementation of Spatial Coordination Incentives for better landscape-scale management while identifying knowledge gaps for future research. We specifically attempt to investigate: (1) What specific incentives have been conceptualized in the available literature for enhanced spatial coordination? (2) Which types of Spatial Coordination Incentives have been implemented in real-world conditions? (3) How well do Spatial Coordination Incentives perform in delivering environmental outcomes at landscape scale? (4) What does the available literature suggest about the underlying enabling conditions for or barriers to the performance of Spatial Coordination Incentives? Insights learned from the review could be useful to inform the design of AES for better delivery of environmental public goods at landscape scale and to set the agenda for future research.

2. Methods and data

2.1. A guiding conceptual framework

The provision of Environmental Public Goods, such as wetlands and wildlife habitats, scenic landscapes, clean water, and clean air have not been supplied adequately by the market, relative to their most socially desirable levels of supply (Westhoek et al., 2013). The standard economic literature highlighting the underlying institutional challenge of such under-production is that most environmental public goods have no clear property rights attached, and are characterized by non-rivalry and/or non-excludability in consumption. The goods, therefore, suffer from the presence of externalities. This triggers the temptation by private landholders to free ride on others' efforts. That is, they tend to conceal their true preferences for the goods to wait for others to step forward and provide them. They can then benefit from or enjoy the goods free of charge. Markets, therefore, fail to provide socially-desirable (efficient) environmental outcomes.

AES have been promoted as a remedy to correct for such market failures by compensating landholders for the income they forgo when carrying out conservation actions. However, individual payments might not be able to create enough potential gains for coordinated conservation actions among neighbouring landholders. By contrast, AES with the inclusion of Spatial Coordination Incentives accounts for spatial externalities that make conservation actions of neighbouring landholders more attractive or rewarding for them. Spatial Coordination Incentives could thus potentially address the problem of free-riding and create enabling conditions for individual changes in resource allocation to cohere into collective action for specifically scaled conservation outcomes.

A theory of change approach, known as "a theory of how and why an initiative works", was first introduced in the field of community development in the 1990 s (Weiss, 1995). It is a decision support tool that describes the causal links and the set of assumptions needed for a policy intervention to achieve the desired outcomes and long-term goals (Wunder et al., 2020). We adopt this approach to build a conceptual framework for our review and enable a better understanding of contexts and underlying assumptions/conditions for Spatial Coordination Incentives to achieve the desired environmental outcomes at a landscape scale (See Fig. 1).

2.1.1. Methods

We carried out a systematic review of the literature using the "Preferred Reporting Items for Systematic Reviews and Meta-analysis" (PRISMA) guidelines proposed by Moher et al. (2015). The review includes peer-reviewed journal articles, conference papers, and working papers. We limited our review to papers written in English. The review was conducted in four stages. In the first stage (INDENTIFICATION), we performed an extensive search in Google Scholar and Web of Science databases using the following keywords: "Agri-Environmental Schemes", "Payments for Ecosystem Services", "Agglomeration Bonus", "Threshold Bonus, "Threshold Payment", "Agglomeration Payment",

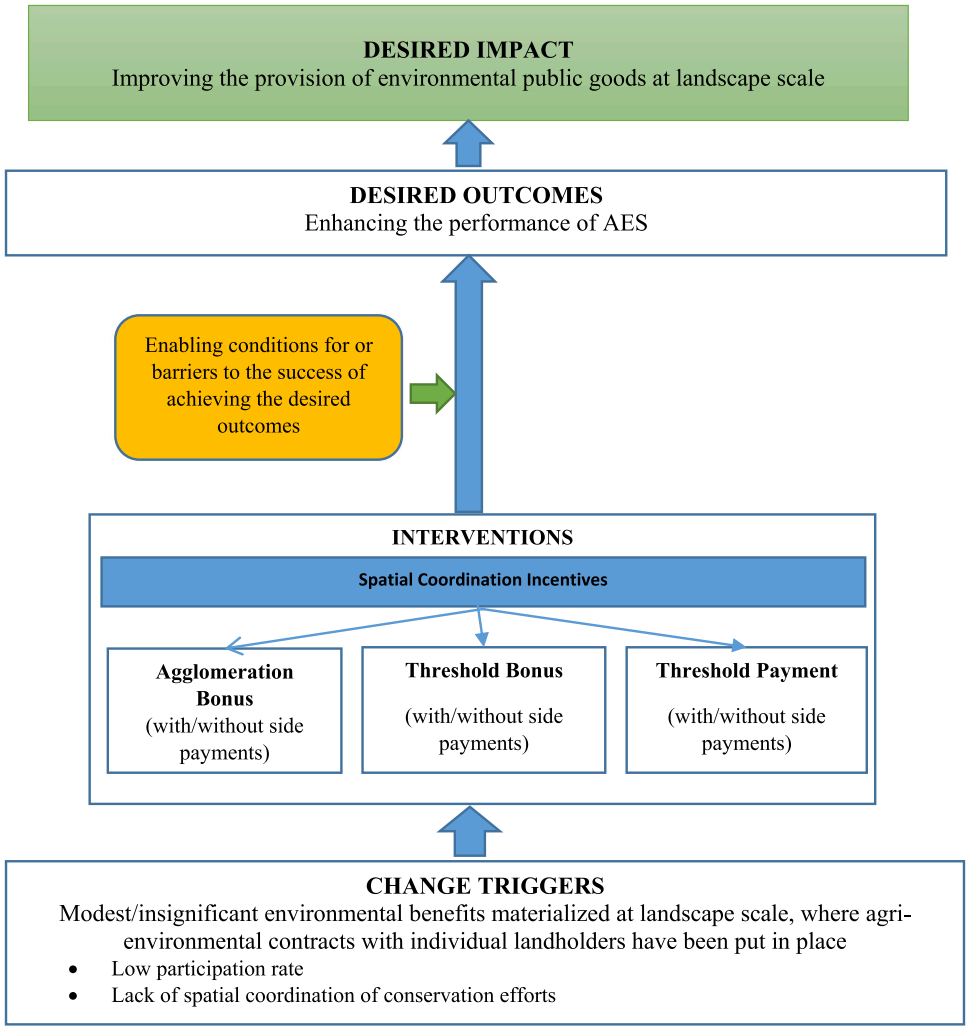

Fig. 1. A guiding conceptual framework for Spatial Coordination Incentives.

"Spatial Coordination", "Spatial Incentives", "Coalition Incentives", "Coordination Incentives", and "Cooperation Incentives". These key words were combined with the Boolean operators OR and AND: ALL= (((Agri-environment* schemes) OR (Payments for ecosystem services)) AND ((Agglomeration) OR (Agglomeration Bonus) OR (Threshold) OR (Threshold Bonus) OR (Threshold Payment) OR (Spatial Coordination) OR (Spatial Incentives) OR (Coalition Incentives) OR (Coordination Incentives) OR (Cooperation Incentives))). Google search and ResearchGate search were also employed to search for additional peer-reviewed conference papers and working papers. After removing duplicate papers (i.e. conference papers or working papers that have been published in peer-reviewed journals), a total of 273 papers were found. In the second stage (SCREENING), we screened the titles and abstracts of these 273 papers. 189 papers were excluded that did not mention economic incentives for enhancing spatial coordination or that discussed collaborative conservation approach rather than coordination approaches, or that discussed economic incentives in other areas (e.g. labour economics) rather than environmental conservation, or that reviewed different aspects of AES (e.g. permanance or leakage issues). In the third stage (ELIGIBILITY), we reviewed the full texts of the remaining 84 papers for eligibility. We further excluded those that did not explicitly discuss the design, implementation, or performance of any of the relevant Spatial Coordination Incentives (i.e. Agglomeration Bonus, Agglomeration Payment, and Threshold Payment). Finally, in the fourth stage (INCLUDED), 55 peer-reviewed papers investigating the above Spatial Coordination Incentives were included in the final review for quantitative analysis. Detailed information about the study's selection process is provided in the PRISMA diagram (Fig. 1). The corresponding PRISMA checklist is provided in Appendix A.

An inductive approach was employed to analyze the literature. Specifically, the 55 final papers were first imported into ATLAS.ti (version 9), a qualitative data analysis software package (Friese, 2019). We read through the papers line by line and assigned codes to paragraphs or text segments. Fifty-one opening codes relating to the performance of Spatial Coordination Incentives and their driving factors were identified. These codes were then grouped into 16 themes (main codes) reflecting the three types of Spatial Coordination Incentives (i.e. Agglomeration Bonus, Threshold Bonus, and Threshold Payment), the seven performance criteria (i.e. participation, spatial coordination, environmental effectiveness, cost-effectiveness, leakage issues, fairness, and social welfare), and the seven driving groups of enabling factors for or barriers to the performance of Spatial Coordination Incentives (i.e. management goals, landscape characteristics, types and amount of information provision, allocation mechanism, economic factors, landholders' characteristics, and collective governance arrangements).

2.1.2. Data

There is a growing number of papers on Spatial Coordination

Incentives. The number of papers over the period from 2001 to 2021 increased from 3 papers in 2001–2005–29 papers in 2016–2021 – almost a tenfold increase. However, empirical studies[1] are still thin on the ground, accounting for only 10% of the literature (i.e. 6 papers out of 55 papers). The literature has mainly focused therefore on theoretical[2] and experimental[3] analyses. Among the three types of Spatial Coordination Incentives, the Agglomeration Bonus has been researched much more than Threshold Bonus and Threshold Payment (See Appendix B for the details of the reviewed papers classified by the different types of Spatial Coordination Incentives). (Fig. 2).

3. Results and discussions

The overall findings of the reviewed papers have been summarized into three sections: features of spatial coordination incentives; evidence of their performance; and underlying factors influencing their performance.

3.1. Features of Spatial Coordination incentives

Table 1 shows different options for the design features of Spatial Coordination Incentives schemes. These design features are elaborated below.

3.1.1. Types of Spatial Coordination Incentives

Smith and Shogren (2001), in their seminal theoretical paper, proposed the idea of an Agglomeration Bonus to address the problem of fragmented conservation efforts. They suggested a bonus that should be paid to landholders on top of participation payments if landholders coordinate to place contiguous plots under conservation. Since then, the concept of Agglomeration Bonus to incentivize adjacent landholders to engage in conservation activities has received increased attention both from theoretical and empirical research.

The literature has discussed different ways of rewarding landholders so as to offer them the best incentive for enhancing spatially coordinated conservation (de Vries and Hanley, 2016). It is suggested that a bonus payment can be paid independently of a standard (fixed) payment to an individual landholder if his/her habitat is spatially connected to the neighbours' habitat (i.e. an Agglomeration Bonus), or if a certain level of participation and/or spatial connectivity among landholders' habitats is reached (i.e. a Threshold Bonus). The Threshold Bonus that the literature has discussed so far is a non-competitive Threshold Bonus. This means that as long as the total outcome achieved by a group of landholders surpasses a pre-defined threshold, the group will receive a bonus irrespective of the performance of other groups. However, one might think to introduce a competitive Threshold Bonus that will be paid to a group of landholders if that group is the best performing across all groups in terms of participation rate and/or degree of spatial connectivity. The comparison between groups creates a threshold effect that is not pre-defined by the regulator.

Instead of offering a bonus payment, Spatial Coordination Incentives can alternatively be designed as an all-or-nothing payment (a so-called Threshold Payment). A Threshold Payment is made to landholders only if a certain level of participation and/or spatial connectivity at the landscape level is reached. Landholders are thus at risk of receiving nothing if such a pre-defined threshold is not met (Wätzold and Drechsler, 2014). In order to account for landscape heterogeneity, in particular, heterogeneity in opportunity costs (income forgone) when implementing conservation activities across landholders, the literature suggests that Spatial Coordination Incentives can include side payments (Drechsler et al., 2010a, 2010b; Wätzold and Drechsler, 2014). Landholders with low conservation costs can transfer part of their payment in the form of side payments to the high-cost landholders to induce them to include their farm in the conservation program if this participation increases overall payoffs.

It is worth noting that if a threshold is defined based on a certain level of participation rather than a certain level of spatial connectivity, then the Threshold Bonus and Threshold Payment will primarily aim to boost participation, which is in turn expected to enhance spatial connectivity of conservation efforts across a landscape (as a greater percentage of patches in a landscape are enrolled, the probability of spatial connection between enrolled patches increases). For instance, in Kuhfuss et al. (2015)'s paper, Threshold Bonus is paid if 50% of the area of interest is engaged in a process of herbicide use reduction.

3.1.2. Exogenous vs endogenous approach

A spatial coordination bonus payment can be of two types: an exogenous bonus and an endogenous bonus. While the former is a direct pecuniary payment, the latter is an indirect pecuniary one. To be specific, an exogenous bonus is paid to landholders for every plot a landholder retires that borders on any other retired plots. Government fixes the size of a monetary bonus. The literature shows that the level of the exogenous bonus relative to the payment for participation varies significantly across studies. One of the greatest challenges for policymakers is, therefore, how to determine the optimal size of the exogenous bonus to induce the highest level of spatial coordination at the lowest possible cost.

By contrast, an endogenous bonus is implicitly reflected by an increment in the imputed environmental value of contiguous plots. The increment must be defined by the competent authority and will vary depending on the conservation target. Banerjee et al. (2009) proposed an endogenous bonus mechanism (The Agglomeration Vickrey Auction) that explicitly considers in the rules of the auction the increment in environmental benefits from enrolling adjacent farmlands. Similarly, Iftekhar and Tisdell (2016) revealed to landholders that the goal of the auction was to establish corridors for better spatial management, thereby introducing an endogenous bonus for spatial coordination. Lewis et al. (2011) incorporated environmental benefit information into the selection criteria of a conservation program to induce agglomeration of conserved habitats.

Unlike an exogenous bonus with a direct pecuniary incentive, an endogenous bonus works as a signal to landholders that their plots, if they are contiguous to others, will have a higher chance of being selected, since they can deliver a better environmental outcome which is valued by the regulator. When contracts are allocated based on competitive bidding, the information relating to the increment in environmental value is revealed to landholders so that they can make their own decision on how much they want to be compensated for offering their contiguous plots for conservation purposes. If landholders know that the environmental value of a plot (which depends on its environmental value and the environmental bonus as a result of the spatial coordination effect) is very high, they will be inclined to tender a higher bid, knowing that they are offering a service of "high quality". Since the bonus is endogenized by bidders, we term it an endogenous bonus.

Similar to a bonus payment, a Threshold Payment can also be made to landholders either via the exogenous approach (i.e. payment level fixed by the government) or the endogenous approach, where landholders will decide on how much they want to be compensated for their collective conservation activities via joint bidding. The literature to date has mainly focused on the exogenous approach (45 out of 55 papers) and has paid less attention to the endogenous approach for boosting spatial

[1] Empirical studies generate observations, make measurements and demonstrate relationships among observed variables, typically using statistical methods (Haller, 2014).

[2] Theoretical studies do not depend on an experiment or on empirical evidence. It is based on testing, exploring or developing theories. It includes computer simulations (Haller, 2014).

[3] Experimental studies generate observations that are collected via lab or field work in a hypothetical setup, rather than in real-life experience, but involving real people and observing their behaviour (Haller, 2014).

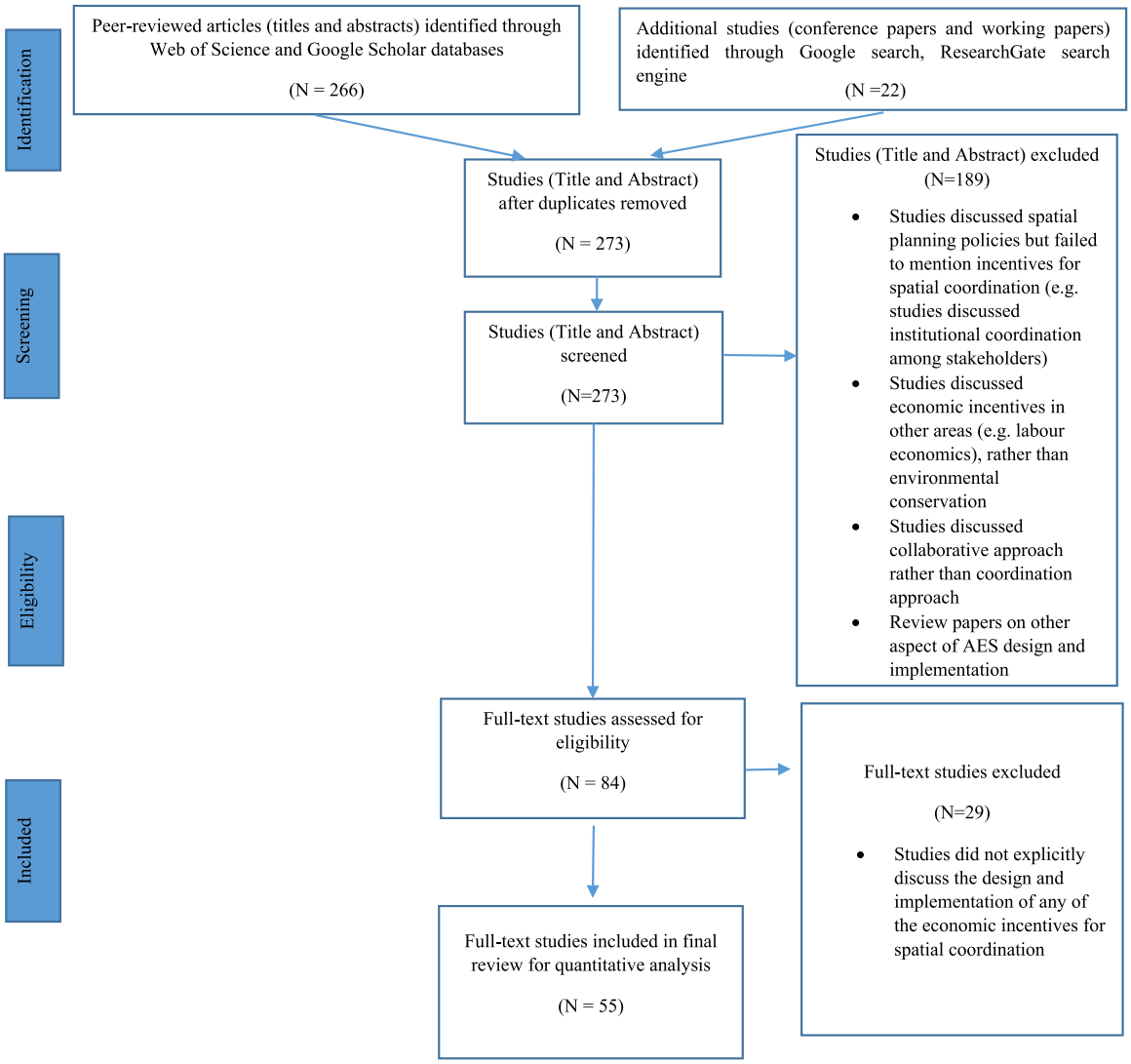

Fig. 2. Description of selection and exclusion methodology for literature review of studies discussing the design and implementation of the economic incentives for spatial coordination of conservation efforts.

Table 1
Spatial Coordination Incentives with different design features.

Type of Spatial Coordination Incentives	Payment approach		Allocation mechanism		Payment mechanism		Institutions	
	Endogenous	Exogenous	Auction	Non-auction	Action-based	Results-based	Collaborative governance	Command-and-control governance
Agglomeration Bonus	✓	✓	✓	✓	✓		✓	✓
Threshold Bonus		✓		✓	✓			✓
Threshold Payment		✓		✓	✓			✓

Note: The design features discussed in the literature are indicated by a tick

coordination (See Appendix C for classification of the reviewed studies according to payment approach).

3.1.3. *Allocation mechanism*

AES with the inclusion of Spatial Coordination Incentives can be a standard-based or an auction-based allocation mechanism. Although standard payments have often been adopted due to their apparent simplicity for scheme design and management on the side of policy makers (Liu et al., 2019), standard payments may create an adverse selection problem (Lundberg et al., 2018). Some landholders are over-compensated for their participation due to information asymmetry about compliance costs between landholders and the government. Standard payments might also be unable to incentivize participation of landholders whose land, due to its location, has critical value for achieving spatial conservation targets (de Vries and Hanley, 2016). By contrast, auctions have long been advocated as an alternative allocation mechanism to avoid the problem of adverse selection and improve the cost-effectiveness of conservation programs by fostering competition between landholders (Hanley et al., 2012; Latacz-Lohmann and Van der Hamsvoort, 1998; Rolfe et al., 2017; Schilizzi and Latacz-Lohmann, 2013). There is evidence to believe that (reverse) auction mechanisms are capable of promoting spatial coordination while maintaining competition (Reeson et al., 2011). However, uptake and diffusion of conservation auctions as a way to allocate conservation contracts has

been slow (Rolfe et al., 2018). Spatial coordination among landholders to deliver better environmental outcomes has received relatively scant attention in the design of conservation auctions (de Vries and Hanley, 2016; Iftekhar and Tisdell, 2014; Banerjee et al., 2009). In a recent paper, Liu et al. (2019) emphasized that the discussion of Spatial Coordination Incentives in auctions is still in its infancy.

3.1.4. Action-based versus results-based payments

AES have traditionally been implemented as action-based programmes, which remunerate landholders for generating specific environmentally friendly land management practices rather than for generating actual environmental outcomes (O'Rourke and Finn, 2020). However, action-based payment mechanisms have been criticized for poor targeting (weak or uncertain correlation between conservation actions and environmental enhancement), adverse selection (hidden information), and moral hazard (hidden action) (Batáry et al., 2015; Hart and Latacz-Lohmann, 2005). Consequently, action-based AES are often found to be unable to deliver the desired environmental outcomes, not to mention the widespread phenomenon of poor additionality (Kleijn and Sutherland, 2003; Poláková et al., 2011). The proposal to link payments to environmental outcomes has been adopted in some parts of the world. There is evidence suggesting that results-based schemes will be able to deliver better environmental outcomes at a landscape scale than action-based schemes (Herzon et al., 2018; Matzdorf and Lorenz, 2010). The shift from an action-based to a result-based payment has been seen as the way forward for future AES design. However, to date, Spatial Coordination Incentives have only been discussed in the literature in the context of traditional action-based payments.

3.1.5. Institutional arrangements

Collaborative governance refers to institutional arrangements where landholders, together with other stakeholders (e.g. advisors and government officials) are engaged in the design and implementation of AES, allowing more inclusive decision making. The adoption of a collaborative governance approach, instead of a common-and-control (hierarchical) approach, is expected to enhance the spatial fit of AES, aligning the scale of policy interventions with the scale of the managed ecological services (Westerink et al., 2017). For instance, some Agglomeration Bonus schemes in Switzerland allow farmers to become involved in collaborative scheme planning with members of local communities, farm advisors, and members of ecological planning firms (Huber et al., 2021).

3.2. Real-world applications of Spatial Coordination Incentives

Table 2 presents the different types of Spatial Coordination Incentives and their corresponding real-world applications. We found that, to date, the adoption of these incentives in the practice of conservation contracting is very rare, and side payments, in particular, have not yet been used in any real AES. With the exception of Malawi (Bell et al., 2018a, 2018b, 2018c), Spatial Coordination Incentives have so far only been implemented in developed countries.

Specifically, Switzerland and Malawi are the pioneers of the Agglomeration Bonus program implementation (Krämer and Wätzold, 2018). The Swiss Network Bonus scheme was implemented in 2001. The ecological network bonus offers landholders an additional payment if their farmland is a part of a contiguous habitat network. Similarly, Smart Subsidies for Catchment Conservation program in the Shrine River Basin, Malawi, offers bonuses to adopters whose neighbours also adopt conservation farming practices, such as inter-cropping, zero tillage, and

Table 2
Real-world applications of Spatial Coordination Incentives.

Type of economic incentive		Definition	Real-world applications
Bonus	**Agglomeration Bonus** * without side payments	A bonus is paid to farmers on top of a fixed payment if conserved habitats are spatially connected in a predefined way	**Switzerland:** The Swiss Network Bonus scheme was implemented in 2001. **Malawi:** Smart Subsidies for Catchment Conservation in the Shrine River Basin
Bonus	**Agglomeration Bonus** with side payments	A bonus is paid to farmers on top of a fixed payment if conserved habitats are spatially connected in a predefined way. In order to induce high-cost landholders to participate, low-cost landholders may offer some of their potential profits in the form of side payments to the high-cost landowners, so that the sum of profits is increased. Side payments can be either pecuniary or non-pecuniary payments.	Agglomeration Bonus with side payments have not been introduced to the design of any real AES. Only theoretical works studying this type of bonus were found.
Bonus	**Threshold Bonus**	A bonus is paid to landholders (in groups or as individuals) on top of a standard (fixed) payment if a certain level of participation or spatial connectivity at group (landscape) level is reached.	**United States:** Conservation Reserve Enhancement Program (CREP) in Oregon was implemented in 1998 **Australia:** Dryland salinity credit trade scheme was implemented in 2005. The Australian auction in the Desert Uplands of Queensland (2006–2008) **Mexico:** Mexico's federal Payments for Hydrological Services program (PSAH) was implemented in 2003.
All-or-nothing payments	**Threshold Payments** without side payments	Threshold payments (All-or-nothing payments) are made only if a certain level of participation and spatial connectivity at group (landscape) level is reached.	**Japan:** The Kuma Joint Management Program (KJMP) was implemented in 2006
All-or-nothing payments	**Threshold payments** with side payments	Threshold payments are made to a group of people only if a certain level of participation and spatial connectivity at group (landscape) level is reached. In order to induce high-cost landholders to participate, low-cost landholders may offer some of their potential profits in the form of side payments to the high-cost landowners, so that altogether their profits are positive. Side payments can be either pecuniary or non-pecuniary payments.	No real-world applications

Note: *Agglomeration Malus (AM), proposed by Bamière et al. (2013), is an opposite variant of Agglomeration Bonus. Under an AM scheme, an amount of payment will be deducted from a standard payment received by landholders if the conserved parcels are adjacent to each other. This type of incentive mechanism is relevant the cases where the fragmented landscape is desirable

crop residue mulching (Bell et al., 2018a, 2018b, 2018c).

The United States is the leading country in introducing a Threshold Bonus to boost participation and contiguity of conservation activities. The Conservation Reserve Enhancement Program (CREP) in Oregon was implemented in 1998. It aims to restore contiguous riparian buffers along with stream habitats by providing a Threshold Bonus if at least 50% of any five-mile section of stream area is put under conservation by landholders (Bucholtz et al., 2010). Adopting the idea of Threshold Bonus, in 2003, Mexico's federal Payments for Hydrological Services program (PSAH), which aims to improve water quality and quantity for downstream communities, awarded extra ecological points to adjacent landholders who jointly enrolled in the program (Sims et al., 2014). In 2005, Australia implemented the Dryland Salinity Credit Trade Scheme with the inclusion of Threshold Bonus in its design. Under this scheme, landholders met a salinity recharge obligation either through compliant land management action or offset deficits in on-site reduction through the purchase of additional salinity recharge credits. If land management change (e.g. new pasture establishment and management, a farm forestry establishment and management) and trading occur to the extent necessary to meet a defined collective aggregated recharge reduction target, all participants receive a bonus payment. Moreover, Australia is also among the most experienced countries using auction-based mechanisms to promote conservation activities. They ran an auction program aiming to create habitat corridors and stepping stones in the Desert Uplands of Queensland from 2006 to 2008. In this program, they introduced an endogenous bonus to achieve the desired patterns of land use by incorporating the increment in the environmental benefits owing to spatial coordination of conservation efforts into the management goal of the auction, and thus into the scoring of bids and the awarding of contracts (Windle et al., 2009).

Instead of using a bonus payment to foster participation and spatial coordination, Japan adopted a Threshold Payment in the Kuma Joint Management Program (KJMP) in 2006 (Shimada, 2020). The program rewarded forest owners with lump-sum payments for implementing joint forest management of large parcels. Otherwise, no payments were made.

3.3. Performance of Spatial Coordination Incentives

Table 3 summarizes the performance of Spatial Coordination Incentives corresponding to different performance criteria identified in the literature. The theoretical and empirical studies offer consistent results, suggesting the high potential of Spatial Coordination Incentives in enhancing participation, spatial coordination, and environmental effectiveness. By contrast, the results derived from the experimental studies on these three performance criteria are mixed for the Agglomeration Bonus and Threshold Payments. Generalizing the positive outcomes of these innovative incentive mechanisms should therefore be considered with caution. The cost-effectiveness of Spatial Coordination Incentives has been a subject of debate in both the theoretical and experimental literature, with some studies indicating enhanced cost-effectiveness, others suggesting reduced cost-effectiveness, and still, others finding no effect at all. No evaluation on cost-effectiveness has been conducted for the few real-world schemes. There are only 3 papers, which studied leakage issues, distributional effects, and social welfare effects of Spatial Coordination Incentives. Reducing leakages and improving fairness and social welfare are the positive outcomes suggested by the available literature.

The findings across different types of studies are synthesized and discussed in detail below.

3.3.1. Theoretical studies

Theoretical analyses have provided predictions about the performance of Agglomeration Bonus in promoting the spatial connectivity of conservation activities. The Agglomeration Bonus was also predicted to ease compliance monitoring by creating peer pressure among landholders, thereby creating incentives for self-monitoring (Bell et al., 2016). The Agglomeration Bonus thus has the potential to work as a diffusion mechanism for spatially coordinated conservation actions more effectively and at lower monitoring costs compared to conventional fixed payments.

Together with boosting spatial coordination, another way of improving the effectiveness of AES at the landscape scale is to reduce the risk of environmentally damaging actions re-locating outside the policy target area, an effect known as leakage. Leakages have challenged the effectiveness of many conservation programs (Le Velly et al., 2017). For example, reduction of deforestation in one area leads to increasing rates of deforestation in adjacent areas. This leakage may be incentivized by the increase in timber prices due to the reduced supply of timber in the market. In this regard, the results of the theoretical model set up by Delacote et al. (2016) suggested that Agglomeration Bonus schemes are more effective than simple participation payments in reducing the

Table 3
A summary of the performance of Spatial Coordination Incentives in the available literature.

	Participation (1)	Spatial Coordination (2)	Environmental Effectiveness (3)	Cost-effectiveness (4)	Leakages (5)	Fairness (6)	Social welfare (7)
Theoretical studies (20)							
Agglomeration Bonus	Positive	Positive	Positive	Mixed results (positive and negative)	Positive		
Threshold Bonus		Positive					
Threshold Payment		Mixed results (positive and no effect		Positive			Positive
Experimental studies (29)							
Agglomeration Bonus	Mixed results (positive and negative)	Mixed results (positive and no effect	Mixed results (positive, negative, and no effect	Mixed results (positive, negative, and no effect			
Threshold Bonus	Positive	Positive	Positive	Positive			
Threshold Payment	Mixed results (positive and no effect	Mixed results (positive and no effect	Positive	Negative		Positive	
Empirical studies (6)							
Agglomeration Bonus	Positive	Positive	Positive				
Threshold Bonus	Positive	Positive	Positive				
Threshold Payment	Positive	Positive					

Note: (1) Participation: number of participating landholders in the scheme; (2) Spatial coordination: Number of shared borders between conserved parcels; (3) Environmental effectiveness: Environmental benefits delivered by the schemes (e.g. number of bird nests conserved); (4) Cost-effectiveness: environmental benefits per unit of government outlay; (5) Leakage: environmental damages are displaced to areas outside the conserved farms; (6) Fairness: Income distribution between participating landholders; (7) Social welfare: Difference between the monetized environmental benefit and the conservation costs incurred by landholders.

activity-shifting leakage problem within the policy target area because the negative spatial interactions between neighbours will be reduced. However, no attempt has been made to investigate whether Agglomeration Bonus prevents or enhances leakages outside the intervention area.

Even though Agglomeration Bonus could potentially achieve spatially connected configuration of land uses on private farmlands, Smith and Shogren (2001, 2002) warned that the performance of Agglomeration Bonus can deteriorate if the landholders know the regulator's preferences for the spatial configuration of farmland under contract. Knowing this information might foster landholders' rent-seeking behaviour. Landholders might collude on the decision to take part in or hold out for higher payments, undermining the cost-effectiveness of AES. Indeed, the findings of Iftekhar and Tisdell (2016) suggested that although endogenous Agglomeration Bonus schemes can help achieve corridor outcomes, the schemes perform poorly in terms of cost-effectiveness due to the high rents sought by landholders. In the same vein, Dijk et al. (2017) highlighted the trade-off between environmental effectiveness and cost-effectiveness of Agglomeration Bonus schemes. Their theoretical model suggests that the cost-effectiveness of Agglomeration Bonus is lower compared to that of Threshold Payment and spatially homogenous (i.e. fixed) payments. Wätzold and Drechsler (2014)'s model and simulations suggested that the cost-effectiveness of the Agglomeration Bonus always lies between that of the Threshold Payment and the fixed payments.

Although Threshold Payments have not received as much attention as Agglomeration Bonus, cost-effectiveness is theoretically demonstrated as a comparative advantage of Threshold Payments over other policy instruments such as Agglomeration Bonus, auctions and conventional spatially homogenous payments (Drechsler, 2017a; Wätzold and Drechsler, 2014). However, the Threshold Payment seems to be less likely to deliver as high a level of social welfare as auctions (Drechsler, 2017a). Unlike Agglomeration Bonus and Threshold Payment, theoretical analyses of the performance of Threshold Bonus have not been carried out.

3.3.2. Experimental studies

The experimental literature highlights the advantages of Spatial Coordination Incentives across key performance criteria. Although there is strong agreement on the positive impacts of Spatial Coordination Incentives on participation rates, spatial coordination of conservation activities and environmental benefits, some scholars argued that such positive impacts do not always occur. Specifically, Banerjee et al. (2017a), (2017b), (2017c) indicated that, due to the complexity of Agglomeration Bonus schemes compared to conventional payments, they are likely to incur higher transaction costs (e.g. costs associated with negotiation among neighbours). The authors found that high transaction costs can result in low scheme uptake and poor spatial coordination. Moreover, the ability of the Agglomeration Bonus to achieve coordination onto the desired conservation land use across landowners seems to decline over time. Krawczyk et al. (2016) carried out lab and artefactual field experiments and found that Agglomeration Bonus has a negative effect on environmental benefits and social welfare.

The impacts of Spatial Coordination Incentives on the cost-effectiveness of AES have also been the subject of debate. While data from several studies suggest improvements in cost-effectiveness, there has also been experimental evidence to the contrary. Liu et al. (2019) conducted a framed field experimental auction in China and found that bidders tend to reduce their bids in the hope of receiving an exogenous Agglomeration Bonus, helping improve the cost-effectiveness of the program. The results are consistent with those of Reeson et al. (2011), who employed lab experiments to examine the performance of multiple-round auctions where the selection criteria take into account a spatial environmental bonus and the number of rounds is unknown. They found that multiple-round auctions with such an endogenous bonus can deliver cost-effective environmental outcomes by reducing bidders' rent-seeking behaviour. By contrast, Parkhurst et al. (2016) compared the performance of a tradable set-aside requirement (TSAR) with and without the Agglomeration Bonus. Their results suggest that under the TSAR with a bonus, the regulator spent much more money to achieve higher landscape connectivity and environmental effectiveness than that under the TSAR without a bonus. These findings are in line with those of Banerjee et al. (2015), who found that the inclusion of an endogenous bonus via revealing spatial management goals leads to an intensification of rent-seeking behaviour, reducing the cost-effectiveness of conservation auctions. In the choice experiments carried out with farmers in Northern France, Vaissière et al. (2018) also found that biodiversity offsetting schemes with the inclusion of Threshold Bonus is not cost-effective, compared to those without a bonus.

Improvements in cost-effectiveness of AES is desirable in the context of limited public budgets. However, AES may also need to achieve a balance between short-term efficiency and fairness, since the latter may affect long-term conservation outcomes (Markova-Nenova et al., 2020; Wunder, 2007). Therefore, perceived fairness in terms of distributional impacts of Spatial Coordination Incentives matters for enhancing AES performance in the long run. Our review found that, to date, Ferre et al. (2018), is the only attempt to examine the distributional impacts of constant and variable Threshold Payments (i.e. Threshold Payments that do vary or those that do not vary with the opportunity costs of farmland over time) using artefactual field experiments with farm apprentices in Switzerland. Their results suggest that the constant Threshold Payment leads to lower inequality in incomes than the variable Threshold Payment, whilst the constant Threshold Payment also outperformed the variable Threshold Payment in terms of environmental effectiveness and cost-effectiveness. However, depending on the context, equal or differentiated distributional mechanisms can be perceived as being fairer by different landholders (Schilizzi, 2011). Therefore, we should bear in mind that the relative performance of the constant and variable Threshold Payment in terms of fairness will be context-dependent.

In the literature on AES in general, the debate about whether there will be a trade-off between efficiency and fairness has gained fresh prominence, with many arguing that cost-effectiveness is not necessarily traded off against fairness (Narloch et al., 2013). This issue has not been explicitly investigated in the specific context of Spatial Coordination Incentives. The experimental literature has incorporated heterogeneity in opportunity costs across landholders in the design; however, except for Ferré et al. (2018), the literature has only considered a static setting where opportunity costs remain unchanged over time, which may not be the case in reality.

Evaluating the likely acceptance by landholders of Spatial Coordination Incentives is of importance to avoid policy implementation failures and to achieve the best environmental outcomes at the landscape scale. To date, very little attention has been paid to landholders' preferences for the design of AES with the inclusion of Spatial Coordination Incentives, as well as to how landholders' participation will vary as we change their design. Our review suggests that there are only four studies employing choice experiments to address this issue. Kuhfuss et al. (2015) investigated the preferences of wine growers in France for a Threshold Bonus. A Threshold Bonus was found to have a significantly positive impact on the participation rate in the scheme. The results agree with those of Vaissière et al. (2018), who suggested that a Threshold Bonus increases scheme uptake and spatial coordination of conservation actions - however at the cost of cost-effectiveness. By contrast, Sheremet et al. (2018) examined how landholders (woodland owners) in Finland respond to an Agglomeration Bonus aiming to encourage spatial coordination in disease and pest control. The authors found both positive and negative impacts of an Agglomeration Bonus on participation and emphasized that the impact is context-dependent. Villamayor-Tomas et al. (2019) also did not provide supporting evidence on the positive impacts of Threshold Payments on the participation rate. This study revealed farmers' resistance in Germany, Spain, and Switzerland to coordinate the planting of trees in return for a payment.

While the literature has focused on environmental and economic impacts of Spatial Coordination Incentives, little is known about their social impacts, such as social capital development through the coordination of conservation activities over time, which includes bonding social capital (between landholders), bridging social capital (between local communities), and linking social capital (local community and institutions). Since Spatial Coordination Incentives can encourage landholders to coordinate their conservation efforts, one might ask whether such incentives can be seen as a way to invest in social capital (social connectedness), and which type of Spatial Coordination Incentives can best promote which type of social capital. Moreover, an isolated individual participating in an AES may not be able to foster social connectedness among landholders as well as spatially coordinated participation. Another question thus arises, whether Spatial Coordination Incentives can promote greater social capital benefits than conventional spatially homogenous incentives. Addressing these research questions is of importance for future research. This is because the literature on conventional AES has highlighted an end-of-contract effect that very often occurs after the schemes terminate (Chervier et al., 2019). There is evidence suggesting that although conventional incentives can trigger behavioural changes in the short-term, they seem to be unsuccessful in shifting attitudinal changes among landholders in the long term. In some cases, norms of "just do conservation for the money" were formed. Economic incentives can become counterproductive when they undermine landholders' intrinsic motivation for conservation whenever it exists. Without positive changes in social norms towards environmental actions, people often stop conservation activities and revert to their old practices when economic incentives end (Pretty and Smith, 2004). The long-term environmental benefits achieved by AES may thus be compromised. We expect that Spatial Coordination Incentives, by contributing to building social capital and changing social norms could be part of the solution to enhance the long-term persistence of behavioural changes.

3.3.3. Empirical studies with real-world observations

There have been few empirical investigations into whether real-world AES including Spatial Coordination Incentives deliver desired outcomes. This may be attributed to the fact that real-life implementation of Spatial Coordination Incentives is rare, and due to a lack of monitoring data on outcomes. Our review suggests that, to date, Bell et al. (2018a), (2018b), (2018c); Krämer and Wätzold (2018), and Huber et al. (2021) are the only empirical studies examining the performance of real Agglomeration Bonus schemes. Specifically, Bell et al. (2018a), (2018b), (2018c) used a randomized control approach to study the performance of the Agglomeration Bonus trial program in Malawi. They reported that the Agglomeration Bonus enhanced participation in the program. The results corroborate the findings of Krämer and Wätzold (2018) who used a qualitative approach based on the perception and experience of landholders, government officials, and ecologists and found that the Swiss Network Bonus made participation more appealing to landholders relative to no network bonus. The surveyed respondents' perceptions lend support to the theoretical predictions on improving environmental benefits, boosting spatial coordination of conservation activities, fostering the learning process across landholders, and enhancing compliance behaviour. Huber et al. (2021)'s regression analyses confirmed the effectiveness of the Swiss Network Bonus scheme in increasing the scheme's uptake and spatial coordination. However, the cost-effectiveness of real Agglomeration Bonus schemes remains untested.

Real-world Threshold Bonus schemes, including endogenous and exogenous payments, have proven to be capable of incentivizing enrolment of high natural value farmland (Sims et al., 2014), promoting participation, and enhancing spatial connectivity of conserved farmland (Connor et al., 2008; Windle et al., 2009). Similar to the Agglomeration Bonus, the small number of studies (i.e. one qualitative and two quantitative analyses) make it difficult to generalize such positive impacts of Threshold Bonus when there is significant heterogeneity across contexts. This calls for more research to allow a general evaluation of the performance of the Threshold Bonus.

Several lines of evidence also suggest that Threshold Payments increase scheme uptake (Connor et al., 2008; Shimada, 2020). However, increasing scheme uptake does not necessarily mean that environmental outcomes are improved (Engel, 2016). If a Threshold Bonus or a Threshold Payment rewards landholders only for their participation, rather than for success in spatial connectivity, environmental outcomes at landscape scale might not be achieved. Empirical evidence about the impacts of Threshold Payment on spatial coordination, environmental effectiveness, and cost-effectiveness is still lacking.

3.4. Factors affecting the performance of Spatial Coordination Incentives

The considerable variation in the performance of Spatial Coordination Incentives requires an understanding of the underlying factors affecting their performance. Our review has resulted in a synthesis proposing seven groups of factors. They are inter-related or complementary in their impacts on the performance of Spatial Coordination Incentives. Table 4 presents the enabling conditions derived from the literature that are likely to enhance the effectiveness of Spatial Coordination Incentives and also highlights the factors which need more attention from scholars due to the mixed or unknown results.

3.4.1. Management goals: spatial configuration and location of desired habitats

The extent of spatial coordination among landholders induced by Spatial Coordination Incentives is partly determined by the spatial configuration and the location of the desired habitat (Drechsler et al., 2010a, 2010b; Parkhurst and Shogren, 2007). Simple environmental

Table 4
Enabling conditions for improving the performance of Spatial Coordination Incentives.

Groups of factors	Enabling conditions
Management goals	
Complexity of coordination pattern	Simple coordination pattern
Location of the desired habitat	Corridor-style reserve (relative to a single core habitat)
Landscape characteristics	
Ecological characteristics of the conserved landscape	Species with small dispersal Multiple interacting species have low variations in their competition strengths and colonisation rates
Opportunity costs (Production income foregone)	Homogenous opportunity costs across landholders Low opportunity costs
Spatial configuration of opportunity costs and environmental values	Unknown
Type and amount of information provision	
Knowledge about neighbours' actions (within or outside local communities)	Mixed results (depending on what type and amount of information is provided)
Allocation mechanism	
Additive vs marginal incentive mechanism	Marginal incentive mechanism
Auction vs non-auction	Auction
Action-based vs results-based	Unknown
Economic factors	
Bonus size	Mixed results
Transaction costs	Low transaction costs
Side payments	Mixed results
Landholder characteristics	
Social networks	Strong community network
Network size	Small network
Experience with conservation programs	Mixed results
Risk and fairness preferences	Less risk-averse
Fairness preferences	Less inequity-averse
Social norms	Well-established cooperative norms
Institutional arrangements	
Governance arrangements	Having collaborative governance

goals that can ease coordination among landholders will foster greater spatial coordination. For instance, the Agglomeration Bonus was found to be more successful in achieving a corridor-style reserve than a single core habitat reserve (Parkhurst and Shogren, 2007). It is expected that the performance of different types of Spatial Coordination Incentives will vary with conservation targets (e.g. establishing wildlife corridors compared with reducing soil erosion or water pollution). Future research is required to address these remaining knowledge gaps.

3.4.2. Landscape characteristics: ecological characteristics of the conserved landscape, and heterogeneity in opportunity costs and environmental values

The magnitude of biodiversity benefits achieved by Spatial Coordination Incentives likely depends on the ecological characteristics of conserved species. The literature reveals that the Agglomeration Bonus can best improve the delivery of environmental outcomes for species with a small dispersal range (e.g. Large Blue Butterfly habitat in Germany) (Drechsler et al., 2010a, 2010b; Hartig and Drechler 2009). However, the literature has paid far too little attention to the integration of ecological characteristics of the conserved landscape into cost-effectiveness evaluations of Spatial Coordination Incentives. (Drechsler, 2021) is the only paper examining the impacts of the species traits (e.g. competition strengths, colonisation rates, and dispersal range) on the cost-effectiveness of Agglomeration Bonus schemes. The author shows that the cost-effectiveness of Agglomeration Bonus schemes decreases with increasing differences in the variations in the competition strengths and colonisation rates and with increasing mean dispersal range.

Heterogeneity in opportunity costs across the landscape influences the cost-effectiveness of Spatial Coordination Incentives. If cost differences among habitat patches are high, an Agglomeration Payment (without side payments) is less likely to be cost-effective than spatially homogenous payments. This is because the patch restriction effect may dominate the connectivity effect: the former is where in order to achieve spatial coordination of conservation efforts, more costly patches may need to be selected than if habitat patches could be chosen from the entire landscape; the latter is where environmental benefits achieved from spatial connectivity of conserved patches are higher (Wätzold and Drechsler, 2014). In contrast, a landscape with a condensed spatial distribution of low-cost parcels will allow the Agglomeration Bonus to be able to enrol a large number of adjacent habitats (Grout, 2009).

Although the literature has considered heterogeneity in opportunity costs and environmental values across plots in the landscape, the impacts of correlations between environmental values and opportunity costs on the performance of Spatial Coordination Incentives has been neglected. A detailed analysis of the effects of different relative spatial configurations of costs and benefits on the performance of Spatial Coordination Incentives would be an interesting area for future work, since it seems to be an important factor co-determining ecological and economic effectiveness.

3.4.3. Type and amount of information provision

Information exchanges among landholders is proven to have a significant impact on the performance of Spatial Coordination Incentives, particularly information about environmental behaviour of landholders within or outside their local community, and information about the spatial targeting goals set by the regulators. The literature shows both positive and negative impacts of information. Accordingly, the performance of Spatial Coordination Incentives depends on the type of information provided and to whom it is provided. For instance, Banerjee et al. (2014) found that increasing information on neighbours' actions improved the ability of the Agglomeration Bonus to achieve spatial coordination of conservation, but could not prevent the deterioration of this coordination over time. In a conservation auction, Banerjee et al. (2015) indicated that landholders lower their bids when provided with information about their neighbours' winning status in the previous round, thereby improving cost-effectiveness of the scheme. By contrast, Iftekhar and Tisdell (2016) found that public disclosure of the spatial management goal will foster rent-seeking behaviour.

The literature suggests revealing information about the behaviour of neighbouring landholders contributes to the success of Spatial Coordination Incentives. Grout (2009) emphasized that the more certain landholders are about their neighbours' willingness to retire their land, the more likely spatial coordination will succeed. Landholders can be direct (i.e. adjacent) or indirect neighbours (i.e. non-adjacent neighbours within the local community). Information about land use choices of the former was found to have a stronger impact on landholders' decisions than that of the latter. Moreover, receiving information about the decisions of neighbours in another community also affected the performance of Spatial Coordination Incentives. However, the literature provides controversial evidence for the impacts of information about another community. While Banerjee (2017a) (2017b) (2017c) suggests information about landholders' decisions in another community helps increase spatial coordination, Kuhfuss et al. (2020) showed that information about the rank between landholder groups in terms of coordination and environmental outcomes does not improve the performance of an Agglomeration Bonus. More research is required to help establish clearer evidence on this matter.

Using information nudges to activate social norms towards environmentally friendly behaviour has recently emerged as a promising approach for enhancing the performance of conventional AES (Kuhfuss et al., 2016). One might expect that social norms can be leveraged to increase the performance of Spatial Coordination Incentives at fostering spatial coordination and scheme uptake in both the short and the long term. Future work will need to be undertaken to confirm this. Of critical importance, therefore, is the question of what type and amount of information should be provided to be able to activate social norms in such a way that they can promote not only intrinsic motivation but also extrinsic motivation at zero (or lowest) cost. The degree of effectiveness in activating social norms for promoting environmental behaviour may be sensitive to context specifics (Eom et al., 2016). This would also be a useful area for future work.

3.4.4. Allocation mechanism: additive vs marginal incentive mechanism, auction vs non-action, action-based vs results-based mechanism

The payment allocation mechanism plays an important role in improving the performance of Spatial Coordination Incentives. Hartig and Drechsler (2010) assumed sequential land use decisions by two adjacent landholders and investigated the performance of two bonus-sharing mechanisms: an additive incentive mechanism (i.e. the bonus will be shared equally between the two landholders) and a marginal incentive (i.e. the bonus will be paid only to the second landowner who decided to come later and generated the spatial connectivity). The authors found that the latter outperforms the former in terms of spatial coordination and cost-effectiveness and that this effect is more pronounced at higher degrees of cost heterogeneity.

In order to overcome the problems that arise due to information asymmetry between landholders and governments, a conservation auction considered as a cost-revealing mechanism together with an Agglomeration Bonus has been increasingly promoted in the literature. Auction features (e.g. pricing rule (discriminatory vs uniform), bidding format (single-round or multiple-round), bid selection criteria (total bid or net environmental benefit or bid-per-area ratio), bid revision rule (allow/prohibit bidders to revise their bids during intermediate rounds), and flexibility in bid submission (allow/prohibit bidders to submit multiple bids) were found to have a significant impact on the performance of Spatial Coordination Incentives (Iftekhar and Latacz-Lohmann, 2017; Iftekhar and Tisdell, 2014; Krawczyk et al., 2016; Reeson et al., 2011).

The literature has thus far largely ignored the performance of result-based AES that include Spatial Coordination Incentives. One of the critical shortcomings challenging the effectiveness of results-based payment schemes is the increased risk to landholders (Burton and

Schwarz, 2013). The outcome of landholders' actions usually depends on several factors that are beyond their control, such as the actions of neighbouring landholders or the ability of target species to disperse. Such risks may be reduced by offering a bonus payment or a Threshold Payment for a certain level of participation or spatial connectivity at group level. Further experimental research is thus required to investigate whether Spatial Coordination Incentives can be used as a means for landscape-level risk mitigation to enhance the performance of results-based schemes.

3.4.5. Economic factors: bonus size, transaction costs, budget size, side payments

Transaction costs, payment size, budget size, and side payments are influential economic factors that affect the performance of Spatial Coordination Incentives. Villamayor-Tomas et al. (2019) explained that landholder resistance to take part in a Threshold Payment program is partly attributed to the high transaction costs required for coordination. This finding is in agreement with that obtained by Banerjee et al. (2017a), (2017b), (2017c) indicating that high transaction costs reduce the effectiveness of Agglomeration Bonus in enhancing spatial coordination. However, the literature leaves us with the question of whether reducing transaction costs can help improve the performance of AES in boosting spatial coordination. In actual agricultural landscapes, landholders often own more than one parcel of land. The presence of transaction costs for enrolling each parcel is likely to motivate landholders to offer only cheap parcels, which might not best enable spatial coordination across the landscape. Therefore, one might think it would be more effective to promote spatial coordination among landholders with the use of a bonus that covers such transaction costs. For future investigations, it is worth examining the performance of a bonus which works as a participation subsidy for increasing landholders' participation rate and improving the likelihood of successful spatial coordination.

The size of payment (i.e. bonus size or Threshold Payment size) was found to have significant impacts on the performance of Spatial Coordination Incentives, especially in terms of cost-effectiveness. The literature suggests that payment size should be large enough to be able to cover the costs incurred by conservation actions (including transaction costs, opportunity costs, and direct costs of implementing conservation activities) and to incentivize landholders to spatially coordinate their conservation efforts. One observes in the literature huge variations across studies in bonus size relative to land values (i.e. opportunity costs) or relative to current standard payments. In particular, the literature reveals that bonus size ranges from 2% to 100% of the opportunity costs or from 167% to 500% of the standard payments. A small Agglomeration Bonus has been found not to improve participation rates and environmental benefits of AES (Dijk et al., 2017; Fooks et al., 2016). However, a large bonus payment will challenge the cost-effectiveness of the scheme, although it can help boost spatial coordination (Banerjee, 2017a, 2017b, 2017c). Setting a high bonus payment but, to respect a limited budget, with a maximum number of plots that each landholder can retire for conservation (5 out of 25 plots), has been proposed in experimental studies (Parkhurst and Shogren, 2005, 2008). The determination of bonus size was found to be significantly influenced by the magnitude of the spill-over effect created by conservation actions. Conservation actions are likely to generate positive externalities to surrounding non-conserved plots, such as conservation increasing the amenities to surrounding landholders, which in turn increase land prices. If such externalities bring at least some benefit, a relatively small Agglomeration Bonus may be sufficient to trigger spatial coordination. Otherwise, a large Agglomeration Bonus is required to avoid the incentive for fragmentation (Panchalingam et al., 2019). An Agglomeration Bonus must be large (relative to the standard payment) when the variations in the competition strengths and colonisation rates do not allow for the coexistence of the multiple interacting species (i.e. superior and inferior competitors) (Drechsler 2021).

In the majority of the studies reviewed, the performance of Spatial Coordination Incentives is examined without taking into account the spatial heterogeneity of externalities created by spatial coordination. It is assumed that the amount of externalities generated by a landholder to his/her neighbour and vice versa as a result of spatial coordination is homogenous. Therefore, homogenous bonus payments are set for all participants of AES. This is likely to be an unrealistic assumption given that heterogeneity in the spatial configuration of environmental values and opportunity costs is often observed in agricultural landscapes. Gueye (2017) therefore suggested a discriminating bonus payment where the bonus size received by each landholder varies depending on characteristics of their own and their neighbours' plots. The author found that a discriminating bonus payment will increase spatial coordination among landholders. As a way to discriminate the bonus payment received by high- and low-cost landholders, side payments allow the bonus to be transferred from low-cost farms to high-cost farms. An Agglomeration Payment with the inclusion of side payments outperformed homogenous payments in terms of cost-effectiveness (Drechsler et al., 2010a, 2010b; Wätzold and Drechsler, 2014).

Together with side payments, budget size was found to be one of the crucial factors determining the performance of Spatial Coordination Incentives relative to that of spatially homogenous payments. The literature reveals an interesting finding, that Spatial Coordination Incentives are superior to a spatially homogenous bonus for achieving cost-effectiveness in the context of a small budget. Such superiority will diminish with increasing budget size (Wätzold and Drechsler, 2014). In reality, where conservation budgets are often limited, the adoption of Spatial Coordination Incentives will be a promising approach.

3.4.6. Landholder characteristics: social networks, network size, experience with conservation programs, risk and fairness preferences

Strong social networks among landholders have been observed to facilitate effective spatial coordination of conservation activities since they can help tackle the problem of incomplete information regarding the behaviour of neighbours. A large number of existing studies recognizes the critical role played by communication in enhancing the effectiveness of an exogenous bonus for spatial coordination. Communication helps reduce uncertainty about neighbouring landholders' willingness to set land aside for conservation (Banerjee, 2017a, 2017b, 2017c; Parkhurst et al., 2002; Warziniack et al., 2007). However, it is worth noting the side effect that communication may have on landholders' bids in an auction mechanism with Agglomeration Bonus, as communication could also facilitate collusion among landholders for rent seeking. In a recent study by Krawczyk et al. (2016), these two effects of communication were found to offset each other, leading to no overall impact of communication on the performance of an endogenous bonus. More empirical studies are therefore needed to validate the conditions under which communication would have positive, negative or no effects on the performance of Spatial Coordination Incentives, including both exogenous and endogenous bonuses.

Thus far, the literature has examined the effect of communication by comparing the results of two treatments: with and without communication. However, in the real world, landholders freely make their own choices to communicate or not. Leaving communication as an option for landholders does not necessarily help improve the performance of Spatial Coordination Incentives. This is simply because communication incurs transaction costs for landholders. Such costs may impede landholders' communication with their neighbours for coordinating conservation activities. The size and nature of such transaction costs relative to the payoffs of spatial coordination is an important determinant of Spatial Coordination Incentives' performance. Future research could usefully assess the performance of Spatial Coordination Incentives when communication is optional, as well as observe to what extent different landholders use this option and how it depends on the structure of landholder networks.

Network size (i.e. number of landholders) is also a factor influencing spatial coordination outcomes of Spatial Coordination Incentives. The

larger the network, the higher is the degree of strategic uncertainty that landholders will face regarding spatial coordination. In a circular network setting, Banerjee et al. (2012) indicated that it is harder to achieve efficient coordination in large networks than in small ones. One may infer that a greater network size also means higher transaction costs borne by landholders via communication. An Agglomeration Bonus applied to small networks is therefore expected to perform better than one applied to large networks (Banerjee et al., 2012). The literature to date has examined the effect of varying network size on the performance of the Agglomeration Bonus, given that the information about neighbours' choices from all periods (past and present) is freely provided to landholders by the regulator. This raises the question of whether Spatial Coordination Incentives would still be able to induce spatial coordination in both small and big networks if information about neighbours' choices can only be acquired through costly communication. And if they do, what is the relative performance of Spatial Coordination Incentives in delivering spatial coordination under small and big networks? Testing the impact of network size in such conditions is strongly recommended for future research.

Except for the work published by Liu et al. (2019), most experimental designs in the literature employed a spatial set-up that could help avoid asymmetric neighbourhood structure, such as a circular network. However, a circular network setting does not reflect real-world landscape settings where an Agglomeration Bonus policy could be introduced. In addition, different network types, for instance, line networks and lattice networks, will provide different strategic settings as landholders will have different numbers of neighbours, thereby facing different strategic uncertainties for spatial coordination (Banerjee, 2017a, 2017b, 2017c). Exploring strategic interactions between landholders for spatial coordination on line networks with an asymmetric neighbourhood structure is, therefore, recommended. It may provide further insights into how landholders' responses to an Agglomeration Bonus may differ, given different degrees of strategic uncertainty.

Given the same initial information, landholders' experience over time influences the performance of Spatial Coordination Incentives. However, the literature has to date revealed mixed evidence on the impact of such experience. On the one hand, Spatial Coordination Incentives were found to perform better when landholders gain more experience (Parkhurst and Shogren, 2007; Parkhurst et al., 2002; Warziniack et al., 2007). On the other hand, there is also evidence to suggest that experience deteriorates the performance of Spatial Coordination Incentives in inducing spatial coordination over time (Banerjee et al., 2014, 2015). In sum, the impact of landholders' experiences remains ambiguous.

Landholders' risk and fairness preferences are further underlying factors affecting the likelihood of spatial coordination among landholders. The more risk-averse landholders are, the less likely they will coordinate with their neighbours for conservation actions (Ferre et al., 2018). In a landscape where cost heterogeneity is high and landholders are tight-fisted and inequality-averse agents, the introduction of side payments may not work well as high-cost landholders are likely to perceive the surplus transferred by low-cost landholders to be too small. The literature suggests that inequity aversion reduces the performance of an Agglomeration Bonus with side payments (Drechsler, 2017b; Ferre et al., 2018). Moreover, landholders' existing norms about neighbours' cooperative history have been found to be a key factor affecting the performance of Threshold Payment (Villamayor-Tomas et al., 2019). It is worth noting that the risk of not receiving the payment due to coordination failures associated with each type of Spatial Coordination Incentives will be different since the degree of uncertainty about other landholders' behaviour will be greater in a Threshold Payment scheme than in an Agglomeration Bonus or Threshold Bonus scheme. However, to date, little is known about how risk preferences and existing social norms affect landholders' preferences for different types of Spatial Coordination Incentives.

3.4.7. Institutional arrangements: command-and-control vs collaborative governance arrangements

Huber et al. (2021) is the only study investigating the effect of collaborative governance arrangements on the performance of an Agglomeration Bonus. The authors found that the Swiss Network Bonus scheme, which allowed farmers to participate in a collaborative planning process, is likely to generate more conservation synergies of conservation efforts than those which did not facilitate such participation. Collaboration fosters peer pressure on farms with high intensity of agricultural activities to participate in the scheme. Future work should further explore how the collaborative planning process should be operationalized (e.g. power relations between landholders and other stakeholders).

3.5. Suggestions for future research

We have attempted to provide a comprehensive overview of theoretical, experimental and empirical findings for three types of Spatial Coordination Incentives that have in the last two decades received increasing interest in the literature: the Agglomeration Bonus, Threshold Bonus, and Threshold Payment. Our review shows the potential of these Spatial Coordination Incentives in boosting participation and spatially coordinated conservation efforts in both theory and practice. However, there is still much work to be done to confirm and add explicit detail to these findings, since our review also suggests conflicting evidence against these positive outcomes. In particular, the review also reveals that spatial coordination might come at the expense of reduced performance on other performance criteria, such as cost-effectiveness. The results suggest that the adoption of a particular design of Spatial Coordination Incentives should be tailored to specific contextual conditions, such as environmental management goals (e.g. soil erosion mitigation or water quality improvement) and landscape characteristics (e.g. spatial configuration of the landscape and ecological characteristics of conserved species). The review has raised the following key areas in need of further investigation.

First, to date, evidence comes mainly from theoretical and experimental studies. Their findings are not always conclusive and lack generalizability. More theoretical work, especially on the Threshold Bonus, is needed to establish the foundation for experimental and empirical work. The review also highlights the need for more rigorous experimental and empirical evaluation to validate both the absolute performance of each type of Spatial Coordination Incentives and the performance relative to each other. Due to a limited amount of evidence relating to the performance of Spatial Coordination Incentives to various performance criteria, especially cost-effectiveness, leakage issues, distributional consequences, and social welfare, our review motivates a need to further testing of the validity of current findings and the applicability of different types of Spatial Coordination Incentives. An investigation of the cost-efficiency of AES which includes Spatial Coordination Incentives is also desirable for future work.

Second, future studies should investigate the relative performance of an endogenous versus exogenous approach and test whether the combination of both payment approaches can promote better spatial coordination than each alone.

Third, switching from an action-based to a result-based approach has been encouraged as a novel approach to AES implementation. Future work needs to establish whether results-based schemes with the inclusion of different types of Spatial Coordination Incentives perform better than result-based schemes alone in enhancing environmental outcomes.

Fourth, although a growing body of literature has studied the environmental and economic impacts of Spatial Coordination Incentives, there is little scientific understanding of their social impacts, such as enhancing social ties among landholders and what this implies for future needs to coordinate conservation actions. This is, thus, an interesting area for future work.

Last but not least, the review suggests that a better understanding is

needed of how consideration of ecological, economic, and social factors and their interplay influence the performance of Spatial Coordination Incentives. The literature is still in its infancy in exploring under what conditions different types of Spatial Coordination Incentives will perform best. Non-pecuniary factors, such as spatial patterns (i.e. spatial correlation between environmental benefits and opportunity costs of conservation across the landscape), the degree of intrinsic motivation of farmers, social capital, social norms, different types of social networks, and institutional arrangements, have largely been ignored. Future studies should elucidate the impacts of such factors on the performance of Spatial Coordination Incentives.

Similar to spatially homogenous payments, Spatial Coordination Incentives are short-term payments. Can Spatial Coordination Incentives enhance the long-term persistence of behavioural changes when economic incentives end? If so, under what conditions are they able to do so? If not, how would their design have to be adapted to enhance their long-term performance? Addressing these questions would be a much-needed area for future work.

4. Conclusions

The effectiveness of conventional AES in delivering the desired environmental outcomes has been inhibited due to spatial mismatches between the scale of policy interventions and that of ecological processes underlying many ecosystem services. A growing body of the literature has emphasized the need to adopt a landscape-scale approach, as opposed to a farm-scale approach, to achieve the full potential of AES effectiveness. This review has aimed to improve our understanding of the design and implementation of Spatial Coordination Incentives for landscape-scale environmental management, namely Agglomeration Bonus, Threshold Bonus, and Threshold Payment. This shows that Spatial Coordination Incentives can be incorporated endogenously or exogenously into the design of AES, but their real-world implementation is still rare. Theoretical and empirical evidence suggests that they are likely to be effective at inducing spatial coordination of conservation efforts. However, there is no clear consensus about this finding in the experimental studies. The review suggests that Spatial Coordination Incentives can perform differently in terms of participation, spatial coordination, environmental effectiveness, and cost-effectiveness. The performance is dependent on management goals, landscape characteristics, the type and amount of information provided to landholders, the contract allocation mechanism chosen, economic factors, landholders' characteristics, and institutional arrangements.

Due to highly context-specific variation in real-world settings, and since the available literature is scant and largely theoretical and experimental, no general recommendations can be made at this stage in the choice of which particular incentive from the three Spatial Coordination Incentives will work best in any specific real-world setting. Our review emphasizes the need for researchers to further investigate and justify the performance of different types of Spacial Coordination Incentives on different performance criteria. To further improve the utility of the Spatial Coordination Incentives literature, we have highlighted several questions that need to be addressed in future research to enable policy makers to design more effective and efficient programs to tackle environmental problems that require spatial coordination of conservation activities at a wider landscape scale.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2021.105936.

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