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ORIGINAL ARTICLE

An environmental economic geography of Dutch farmer collectives*

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Abstract
Biodiversity-friendly farming requires spatially coordinated land use to effectively deliver landscape-scale environmental benefits such as biodiversity and other ecosystem services. This paper argues that addressing such coordination challenges requires a stronger integration of ecological, economic, and spatial perspectives within geographical science. Using the Dutch agri-environmental scheme (ANLb) as an empirical case, the paper examines the role of farmer collectives as an institutional innovation aimed at improving spatial coordination of conservation measures on privately owned farmland. Since 2016, these collectives have been responsible for coordinating agri-environmental management across regions, aligning farm-level decisions with landscape-scale biodiversity objectives. However, evidence indicates that spatial coordination remains insufficient to meet these objectives, limiting ecological effectiveness at the national scale. This 'implementation gap' is closely linked to economic and behavioral factors, including the voluntary nature of participation, misaligned incentives, and practical constraints at the farm level. The effectiveness of collective approaches depends on achieving sufficient scale and intensity of participation, supported by adaptive and spatially differentiated policy instruments. In conclusion, farmer collectives offer a promising pathway towards more effective landscape-scale biodiversity governance, but their potential depends on closer integration of ecological, economic, and geographical considerations in both research and policy design.

Keywords Nature-inclusive land use · Spatial coordination · Farmer collectives · Agri-environment schemes · Collaboration

JEL classification D71 · Q15 · Q24 · Q57 · R12

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1 Introduction

Agricultural geography has long focused on the spatial organization of farming practices, examining how environmental and economic conditions shape agricultural land use[1] (Grigg 1995; Symons 2018). Historically, this field has conceptualized the natural environment primarily as a resource base, treating factors such as soil, climate, and water supply as inputs in agricultural production rather than dynamic ecological components (Gillmor 2004). This perspective is exemplified by Von Thünen's classical model of agricultural land use, which prioritizes economic efficiency over ecological diversity (Von Thünen 1826). However, in recent decades, agricultural geography has expanded its scope to include broader socio-economic dimensions, leading to the rise of rural geography as a distinct subfield (Woods 2009). This shift has facilitated a more holistic understanding of rural landscapes, integrating considerations of population dynamics, employment, settlement patterns, and environmental conservation (Gillmor 2004).

Despite these advancements, biodiversity has remained a secondary concern within agricultural and rural geography. Put differently, what we observe is that within these two geographical subfields, nature, biodiversity, and natural resources do receive attention; however, the primary emphasis remains on their role in shaping the spatial processes that influence people's experiences and perceptions of contemporary agriculture and rurality. In other words, ecological systems and their associated environmental assets are primarily approached as the physical environment that agriculture exploits and with which it must contend, while also constituting a foundational dimension of rurality by shaping landscapes, territorial practices, and the socio-cultural imaginaries associated with the countryside (Symons 2018). As Woods (2005, p. 110) observes, "we may value the countryside as a 'place of nature'," yet biodiversity per se has rarely been treated as a distinct category of analysis within geography. This is particularly problematic in view of the current biodiversity crisis, where species loss and habitat degradation threaten ecosystem functions essential for agriculture and rural economies (Dasgupta 2021). If rural landscapes are indeed, as Woods suggests, valued as a 'place of nature', they must also be understood as multifunctional spaces that generate vital ecosystem services, including food provision, pollination, biological pest control, soil fertility and structure, water regulation, and habitat provision (Power 2010).

Against this backdrop, the transition from agricultural to rural geography raises the question of whether biodiversity concerns have become more substantively integrated into human geography. This question gains further relevance when considering the broader shift in biodiversity conservation between 1960 and 2010 from a predominantly nature-focused to a more people-centred approach (Mace 2014). Such a shift reflects an increasing recognition of the dynamic interplay between human activities and ecological systems, and of the need to embed biodiversity conservation within agricultural landscapes rather than separating it from them.

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An illustrative but important example of this can be seen in the Netherlands, where farmer collectives integrate agricultural practices with biodiversity conservation (Ministry of Economic Affairs 2016). These collectives are groups of farmers who jointly apply for agri-environmental schemes (AES), a mechanism to compensate farmers for loss of income associated with a less intensive management of land, crops, and livestock that supports biodiversity, ecosystem services, and sustainable agricultural practices), taking collective responsibility for planning, contracting, monitoring, and compliance. In the Netherlands, farmer collectives were formally established in 2015, and serve as intermediaries between government and individual farmers in coordinating conservation measures at the landscape scale. By pooling resources and responsibilities, farmer collectives aim to enhance ecological effectiveness of AES, strengthen farmer engagement, and create strong links between agriculture, biodiversity, and policy (Boonstra et al. 2021; Dik et al. 2022).

In this context, farmer collectives represent a bottom-up form of governance that demonstrates how biodiversity conservation and agricultural production can mutually reinforce each other. Their organisation shows that, under favorable conditions, ecological gains — such as enhanced ecosystem functioning and the provision of ecosystem services (Ali 2023; Elouafi 2024) — can go hand-in-hand with running profitable farm businesses (see BoerenNatuur, n.d.; Diele et al. 2025). In this sense, farmer collectives embody the recognition that farmers are uniquely equipped and well-positioned to shape and maintain land-use practices that foster both biodiversity and sustainable food production.

Building on this broader trend, our analysis turns to the Netherlands where biodiversity-friendly farming and farmer collectives have become prominent examples of how agricultural production and biodiversity conservation can be integrated. However, it is not only our familiarity with the country that makes the Dutch farmer collectives an interesting case. The Netherlands is a major agricultural powerhouse. Although small in size, the Netherlands is the world's second-largest agricultural exporter — in 2025 alone, the value of exported agri-food products amounts to over EUR 135 billion (Jukema et al. 2026). Nowhere else are physical yields per hectare as high as in the Netherlands (PBL 2018). Over the past sixty years, Dutch agriculture has been transformed into a highly productive, knowledge-intensive, internationally competitive, and economically efficient sector (van der Heide et al. 2011). The upscaling and intensification that enabled this transformation has also drastically reshaped the agricultural landscape. The number of Dutch farms has declined sharply: from 410,000 in 1950 to approximately 50,000 today (Berkhout et al. 2024). This decline has been accompanied by large scale land consolidation, an increase in farm scale and intensification of agriculture, (partly) promoted by the Common Agricultural Policy of the European Union (PBL 2024). Today, the dominant development trajectory of Dutch agriculture continues to focus on ensuring sufficient and affordable food while producing for export, with banks and agribusinesses encouraging farmers to adopt highly productive and innovative practices (van der Ploeg 2013; Westerink et al. 2023).

As a result, Dutch agriculture is among the most efficient in the world (van Grinsven et al. 2019). However, this efficiency comes at the cost of significant environmental pressures. High livestock densities and fertilizer use result in nitrate leaching to groundwater, nitrogen and phosphorus runoff to surface waters, and substantial emissions of ammonia, nitrous oxide and methane (Kros et al. 2024). The sector accounts for 91% of total ammonia and 17% of total greenhouse gas emissions in the Netherlands (CBS 2025; Ministry of LVVN 2025), while intensive practices also exacerbate water scarcity, water pollution, and soil degradation (see Verkuil et al. 2024). Moreover, the move towards intensively operated agriculture, land consolidation and drainage of agricultural landscapes caused steep declines in biodiversity, especially farmland bird populations, which have decreased markedly since the 1960s (CLO 2025a). Amid an intensive and highly productive agricultural sector that generates significant negative externalities, the emergence of Dutch farmer collectives as an institutional arrangement is also unique within a wider a European perspective: the Netherlands is one of the few countries where the government has decided that only farmer collectives can be beneficiaries of AES (Dik et al. 2023). In other countries, France and the UK for example, joint contracts are implemented on collectively managed land, including communal pastures (Kelemen et al. 2023).

A substantial amount of information and knowledge about these Dutch initiatives already exists. However, much research focuses on themes such as business models (Polman and Jongeneel 2020; Schrijver et al. 2022), institutional and governance frameworks (Runhaar 2017; Westerink et al. 2020; Vermunt et al. 2022), cultural norms (Westerink et al. 2019) and the reasons for participating (Bouma et al. 2019), or the ecological and environmental outcomes (Erisman et al. 2017; Gies et al. 2025). The spatial dimension of these initiatives, and how it affects socio-ecological outcomes through spatial coordination in land use, is, however, underexplored. Our line of reasoning resonates with the work of Rauscher and Barbier (2010), who integrate a new economic geography model with an ecological-economic model of species diversity to examine how, and through which policy instruments, an optimal spatial allocation of economic activities and natural habitat can be achieved. However, their analysis abstracts from the (cooperative) governance mechanisms through which such spatial allocations are realized in practice. The aim of this article is to provide a succinct account and discussion of that aspect.

Although the Dutch model of farmer collectives represents an innovative institutional arrangement, there remains considerable scope within these collectives to increase the amount of biodiversity (Dik et al. 2025). That is, current practice shows that 'bottom-up' initiatives do not always exploit the full ecological potential of biodiversity and ecosystem services across the wider landscape. This raises an important question: How do farmer collectives influence the effectiveness of top-down AES in improving biodiversity at the landscape level? All this is particularly important when it comes to fostering spatial coordination in land use management.

From an institutional design perspective, the challenge is to engineer 'smart', hybrid arrangements that combine bottom-up collective action with top-down policy instruments in ways that deliver biodiversity benefits both ecologically effectively and economically efficiently (e.g., Parkhurst and Shogren 2008). This requires designing policy arrangements that explicitly account for geographical network externalities — such as the enhanced ecological benefits that arise when the planting of flower-rich field margins alongside arable land and other environmental measures are spatially clustered across adjacent farms — and encourage coordinated land-use planning at the landscape level. When such spatial externalities are optimally exploited, biodiversity gains can be realized where they are most significant. Farmer collectives are pivotal in operationalizing these spatially targeted strategies at the landscape scale. As institutional platforms, they enable coordinated planning and management of land resources based on geographic, ecological, and socio-economic characteristics. By aligning individual land-use decisions within a collective framework, they help internalize spatial spillovers, reduce fragmentation, and ensure that conservation and production objectives are jointly optimized. In this way, farmer collectives bridge the gap between policy design and on-the-ground implementation, facilitating land use patterns that enhance productivity, sustainability, and equity while maximizing biodiversity outcomes.

Our article contributes to this academic and policy debate by focusing on the spatial dimension of Dutch farmer collectives — an aspect that (as mentioned earlier) has so far received relatively little attention. Specifically, we examine how these collectives operate as landscape-based approaches to agro-biodiversity conservation. In so doing, we aim to shed new light on these mechanisms through which spatial coordination can be improved and highlight the implications for the design of financing mechanisms that foster biodiversity agglomeration across agricultural landscapes.

The structure of this paper is as follows. Sect. 2 explores the spatial dimensions of biodiversity. Building on this, Sect. 3 turns to the relationship between biodiversity and agricultural production. Sect. 4 introduces farmer collectives in the Netherlands and examines their role in the spatial organization of biodiversity production. This is followed by an examination of financing instruments for agro-biodiversity in Sect. 5. Sect. 6 provides a synthesis and offers some avenues for future research.

2 Biodiversity, geography and space

The long-term viability of plant and animal species is fundamentally shaped by two critical spatial characteristics of their habitats: (i) the availability of sufficiently large, intact habitat patches, and (ii) the network of corridors and connective elements that enable species dispersal between these patches (CLO 2022).[2] When habitat areas become too small or fragmented, species struggle to maintain viable populations, limiting their ability to move, adapt, and persist in changing environments (Hagen et al. 2012; Tucker et al. 2018). The landscape's spatial composition plays a key role in various ecological processes, and hence has become an increasingly important factor in nature management (Collinge 1998; Opdam et al. 2006).

A key implication of this is the need to develop 'coherent' spatial structures — ecological networks that facilitate species movement, gene flow, and adaptation to environmental changes. However, these ecological networks are increasingly under

[2] We define a patch as "an area with relatively homogeneous environmental conditions in comparison to its surroundings", with no restrictions on location, configuration or size (Riva et al. 2024, p. 2164). In particular situations, and figuratively speaking, fragmented habitat patches can be viewed as a collection of islands in an otherwise inhabitable sea. A corridor is "a 'band' of connected land parcels that links two or more wildlife habitat patches" (Wang et al. 2022, p. 1043). They function, in a sense, as a bridge connecting isolated patches.

pressure due to competing demands for alternative land uses, as habitats suitable for species are often converted to agriculture, infrastructure, and urban development (van der Heide et al. 2003).[3] Indeed, it is precisely because human land use continues to reshape landscapes that ensuring both the preservation of habitat size and the maintenance of ecological connectivity becomes essential for biodiversity conservation. Not only in the short term — allowing individuals within a population to access the necessary to sustain population viability — but also in the long term so that ecological communities can retain the capacity to shift their geographic ranges in response to climate change and other disturbances (Reeson et al. 2011). According to Cook (2002), the effectiveness of the ecological network on biodiversity conservation depends on the

(i) inherent characteristics of the landscape elements that together form the ecological network (i.e., size and type of patches and corridors, vegetative structure, naturalness, etc.);
(ii) interrelationships between landscape elements (i.e., the overall density of suitable patches and corridors, and the extent to which they are linked); and.
(iii) external factors affecting the functioning of the ecological network (i.e., pollution, domestic predators, land use intensity, etc.).

Thus, connectivity extends beyond the mere physical continuity of habitat patches or corridors. Ecological connectivity is determined by both the nature of the surrounding land use — typically agricultural or otherwise modified land — and by the traits of the species or communities involved (Reeson et al. 2011). Size of the patches matter, too. Large, contiguous habitat areas tend to promote ecological stability and natural succession, which is one of the main reasons why conservation efforts have traditionally favored the establishment of large patches (Diamond 1975). However, recent studies highlight the complementary role of small habitat patches in biodiversity conservation (e.g., Fahrig 2020). Small patches may provide refuges for vulnerable species, serve as steppingstones for dispersal or recolonization. Loss of smaller patches can disproportionately reduce landscape diversity compared to minor losses from large habitats (Szangolies et al. 2022).

Groeneveld (2004) shows that ecologists have long grappled with the question of whether it would be beneficial for the conservation of species to divide a given total amount of habitat into one large or several small habitat patches. This is known as the SLOSS (Single Large Or Several Small) problem and has been subject to considerable academic debate (Fahrig et al. 2022; Huber et al. 2025). For instance, in the con-

[3] Nevertheless, it is important to realize that a significant share of the most valued habitats and landscapes in Europe has arisen from agricultural management of the natural environment over centuries (Tilzey 2000). In the Netherlands, for instance, one of the most influential ecologists and conservationists, Victor Westhoff, was convinced that nature management should be based on the Dutch landscape as it was around 1875, when it was still highly diverse. At that time, small-scale agriculture enriched nature, as farmland had been managed in various ways for centuries. Farmers, for example, prevented grasslands from becoming overgrown with trees, allowing a wide variety of plants to thrive. This is, according to Westhoff, precisely how the semi-natural landscapes of the Netherlands should be maintained (van der Maarel and Schaminée 2001).

text of metapopulations dynamics,[4] Ovaskainen (2002) shows that a small number of large patches maximizes the metapopulation capacity, while an intermediate number of habitat patches maximizes the time to extinction. Fahrig (2020) found that several small patches usually hold more species than a few large patches of the same total area. And Szangolies et al. (2022) argue that a combination of single large and several small (SLASS) patches promotes biodiversity by enhancing landscape heterogeneity.

While these studies focus primarily on the size and number of habitat patches, the role of connectivity and the design of corridors between them remains less well understood. Although the potential benefits of a well-connected network of corridors linking detached habitat patches have been widely reported in the literature (e.g., Wang et al. 2023; UNEP-WCMC and IUCN 2024), the 'optimal' spatial design of such corridors has not yet been extensively studied, mainly due to methodological and computational challenges (Wang et al. 2022). Designing effective corridors requires balancing multiple ecological and spatial criteria — such as connectivity, length, width, and habitat quality — while also considering constraints related to land use and economic costs. As a result, identifying optimal configurations at the landscape level often demands advanced modelling and optimization approaches capable of handling spatial complexity and trade-offs.

While the SLOSS debate and research on ecological corridors focus primarily on the spatial configuration of habitat within natural or semi-natural systems, similar questions arise when considering how biodiversity can coexist with agricultural production. This parallel has been captured in the 'land sparing versus land sharing' framework, which extends spatial allocation principles to multifunctional landscapes where conservation and production compete for space. In such landscapes, tensions frequently arise between different land uses, forcing planners and decision-makers to weigh ecological considerations against agricultural, economic, and social objectives (Simensen 2025). Considering this setting, and with biodiversity found mainly in so-called production landscapes (especially agricultural landscapes, see Baudron and Giller 2014), the land sparing–sharing framework offers a structured way to analyze how varying degrees of land-use intensity can be balanced with ecological sustainability. This framework describes two contrasting strategies to minimize trade-offs between increasing agricultural production and conserving biodiversity: land sparing, which concentrates production by increasing yields and thereby reduces the overall demand for farmland, and land sharing, which distributes land uses more evenly across the landscape, allowing for greater biodiversity within agricultural areas but at the cost of lower yields (Baudron et al. 2021).[5]

Although the land sparing versus land sharing debate is often framed as a strict dichotomous choice, land-use planning in practice involves numerous intermediate scenarios shaped by a complex interplay of geographical, ecological, economic, social, and political factors. Few studies provide empirical examples demonstrating

[4] A metapopulation can be loosely defined as a collection of separated local populations of the same species that remain interconnected through dispersal.

[5] See Simensen (2025) for a comprehensive and accessible review of the land sharing versus land sparing dilemma. In the context of geography, the author contends that Von Thünen, through his analysis of the spatial distribution and intensity of different land uses, was arguably the first to articulate this issue explicitly.

the potential of either land sparing or land sharing to reconcile agricultural production with biodiversity conservation (Augustiny et al. 2025). Butsic et al. (2020) show that in landscapes where both agricultural productivity and species distributions vary, purely dichotomous strategies (i.e., strict land sparing or uniform land sharing) rarely achieve optimal outcomes. Hybrid configurations that combine elements of both approaches, however, tend to minimize biodiversity losses while maintaining viable production levels. Indeed, "both approaches need to be combined and integrated into a landscape connectivity matrix that optimizes the spatial linkages between natural habitats and production areas to facilitate movement of species" (Grass et al. 2019, p. 263).

These insights underscore that the balance between agricultural production and biodiversity is inherently context-dependent. Understanding how these dynamics play out in landscapes requires empirical evidence on specific species groups and ecosystems. For instance, recent research on populations of wild bees, bumblebees, hoverflies, and butterflies offers a clear example of how the area and quality of natural habitats shape biodiversity outcomes in agricultural settings (Bishop et al. 2025). For all species groups, the relationship was straightforward: the more natural habitat present, the greater the abundance of pollinators in agricultural landscapes. Habitats with a higher density of flowering plants also supported more pollinators across all groups than areas with few flowers. The authors conclude, however, that it is better to focus on increasing the area of natural habitats first, rather than on managing small patches, even if they contain many flowers. In fact, they state that bees, bumblebees and butterflies need between 16 and 37% of the habitat in an agricultural landscape for effective protection.

The twin-character between space and biodiversity — referring to the idea that biodiversity and spatial dynamics are inherently interconnected — forms the foundation of the fact that biodiversity cannot be fully understood or managed without considering its spatial dimensions, making geography and spatial sciences crucial for biodiversity research and conservation planning. However, whereas natural sciences are increasingly putting emphasis on the importance of spatial factors and geographical phenomena in understanding ecological systems (see, for instance, the field of landscape ecology; Turner 1998), the academic field of geography often uses less distinct ecological concepts and specifications.

This is surprising because "geography belongs to sustainability science and is instrumental in bridging the gap between natural and social sciences" (Ramirez and Lizarazo 2025, p. 2). Nevertheless, despite geography's inherent focus on spatial relationships and environmental interactions, ecological principles and biodiversity considerations are often underrepresented within the discipline. This omission is particularly striking given that geography, as a research field, investigates the organization of space, human-environment interactions, and land use changes — factors that are deeply intertwined with ecological dynamics. However, traditional geographical research — in particular sub-disciplines such as cultural geography, rural geography, economic geography or social geography — has often prioritized economic, political, and social aspects over ecological processes, leading to a fragmented understanding of biodiversity in spatial analyses.

This is in contrast with economics, where since the 1980s the interdisciplinary field of ecological economics has emerged, and wherein natural scientists and social scientists cooperate to tackle the multiple challenges facing human economies and natural ecosystems (van den Bergh 2001). Ecological economics explicitly acknowledges that economic activity depends on ecological systems and natural resources and seeks to develop economic models that account for environmental constraints and biodiversity. As an interdisciplinary field, ecological economics draws on both the natural sciences — such as ecology, population biology, evolutionary biology, genetics, and wildlife and fisheries management — and the social sciences, including sociology and psychology.

The concept of ecosystem services, representing the benefits human populations derive, directly or indirectly, from biodiversity, provides a fruitful intersection between geography and ecological economics. These benefits are inherently spatial in nature, as they arise from specific landscapes and ecosystems and provide benefits to human populations across different locations. However, despite the initiation of several so-called 'atlases' of ecosystem services or natural capital (see, for instance, Brand et al. 2015; Schröter et al. 2019a, b), a systematic geographic analysis of how these services flow from natural capital sources to human beneficiaries — considering spatial distribution, connectivity, and accessibility — remains relatively underdeveloped. The key challenge lies in identifying and understanding the geographic relationships between spatial configurations of ecosystems as suppliers of goods and services and the locations where people live and work, benefiting from these natural processes (Lant 2009). This requires analyzing the potential provision of ecosystem services and how their availability aligns with human demand and the actual use (Schröter et al. 2019a, b). Factors such as distance, landscape connectivity, and land-use patterns all play a crucial role in shaping the accessibility and distribution of ecosystem services. Understanding these spatial dynamics is not only crucial for effective management, policy design, and equitable distribution of ecosystem services, but also for financing biodiversity conservation actions, which we discuss in Sect. 5.

3 Biodiversity and agricultural production: from a one-sided to a reciprocal relationship

Nature plays a fundamental role in agricultural production, not only as an input but also as a system that farmers can actively shape and enhance. Traditionally, nature has been regarded as a provider of essential production factors such as healthy soils, carbon storage, water availability, pest regulation and pollination. These factors are conducive to supporting and enhancing agricultural productivity. Conventional farming often extracts these benefits without replenishing them, leading to soil degradation, loss of biodiversity, and declining ecosystem services (e.g., Tilman et al. 2001; Emmerson et al. 2016; Benton et al. 2021). In fact, large-scale industrial agriculture has increasingly become disconnected from the local ecosystem, relying heavily on external inputs such as artificial fertilizers, concentrated animal feed, and pesticides (van der Heide 2022). The consequence of this is clear: the current model of food production is pushing up against the planetary boundaries, if it has not already exceeded them (Campbell et al. 2017; Gerten et al. 2020). This raises concerns about the long-term sustainability of the conventional agricultural system, suggesting that it may not necessarily be the most suitable model for the future.

But where problems arise, solutions also emerge. Recent approaches in agricultural economics emphasize the reciprocal relationship between farming and nature: while farmers rely on natural resources, they can also contribute to biodiversity conservation in many ways, and even actively ‘produce’ nature through sustainable farming practices (Hanley et al. 2012). Agriculture entails, in other words, not a one-sided relationship of ‘taking’; its partnership with nature should encompass a kind of giving or reciprocity (van Doorn et al. 2016). Hence, in some cases, agricultural landscapes — particularly where farming is practiced extensively or in an agro-ecological way — become sources of newly developed nature, providing habitats for wildlife, improving water retention or water quality, and increasing climate resilience (Bazzan et al. 2023).

Understanding this reciprocal interaction requires a spatial perspective, as biodiversity and ecosystem services are unevenly distributed across landscapes, and their benefits depend on spatial connectivity (e.g., Groeneveld 2004). Conversely, fragmented landscapes with intensive monocultures tend to experience biodiversity loss, reducing resilience to pests, diseases, and climate variability (Gebhardt et al. 2023). Moreover, the spatial configuration of farms influences ecosystem services such as pollination, pest control, and water regulation (Chaplin-Kramer et al. 2015).

These spatial interdependencies imply that, rather than focusing solely on individual farms, a landscape-level approach is essential for preserving biodiversity and strengthening ecosystem resilience (Prager et al. 2012). Although connected habitats are more valuable than isolated ones, because they facilitate species movement and ecological interactions, not all habitat patches contribute equally to that connectivity. Their conservation value depends on the protection of surrounding areas, which is shaped by meta-population dynamics and community complementarity (Armsworth et al. 2004), that is, by their position within the broader spatial network at the landscape level.

Accordingly, to achieve meaningful conservation outcomes, conservation efforts should be targeted at the landscape level (Chomitz et al. 2006; Dallimer et al. 2010; Margules and Pressey 2000). However, effective implementation of policy mechanisms requires careful consideration of land ownership, habitat continuity, and other institutional detail and complexities (Banerjee et al. 2013). Many species’ home ranges and target habitats cross private land boundaries, making individual conservation efforts insufficient. AES — public policy programs that provide financial incentives to farmers for the preservation of the rural environment and biodiversity and maintaining the countryside[6] — must be designed to address these overlaps and prevent habitat fragmentation (Bamière et al. 2013; Cooke and Moon 2015). Encouraging spatial clustering of conservation activities – by incentivizing neighboring landowners to participate – can maximize ecological benefits (Goldman et al. 2007; Warziniack et al. 2007; de Vries and Hanley 2016).

Recognizing the importance of a coordinated approach to biodiversity conservation, the EU Rural Development Regulation introduced in 2014 group applications for farmers and land managers to implement agri-environmental measures (AEMs) — such as the planting of flower-rich field margins, introducing buffer strips (to reduce pesticide loss), or applying a delayed mowing regime on grassland to protect farmland bird nests — on their land.[7] This collective strategy aimed to enhance the effectiveness of AES by improving spatial coordination at the landscape scale, thereby increasing biodiversity (Bazzan et al. 2023; Dik et al. 2025). The rationale behind this approach is that maintaining species richness across larger spatial scales is critical to protecting diverse ecosystems (Sidemo-Holm et al. 2024). Each member state specifies its own arrangements for supporting collaborative approaches (Prager 2015).

One of these countries is the Netherlands, which launched the Agricultural Nature and Landscape Management (‘*Agrarisch Natuur- en Landschapsbeheer’*, ANLb) program on January 1, 2016, as part of the Common Agricultural Policy (CAP).[8] As such, ANLb is the Dutch implementation of an agri-environmental scheme. Its core principle is a habitat-based approach for species of international importance[9], implemented through a collective, spatially-focused strategy. In 2024, out of a total farmer population of 49,900 more than 12,000 farmers voluntarily participated in the ANLb-scheme, jointly implementing AEMs on more than 120,000 hectares of agricultural land (see BoerenNatuur, n.d.). This represents approximately 7% of the total agricultural land area.

A recent study by Visser and Kleyheeg (2025a) indicates that while ANLb supports biodiversity locally, it is insufficient in its current form to reverse the widespread decline of farmland birds and other bird, fish and amphibian species. Although

[6] In the European Union (EU), agri-environmental subsidy schemes have been part of the Common Agricultural Policy (CAP) since 1994. While Member States are required to implement such schemes, they retain flexibility to tailor them to national or regional priorities (Alblas and van Zeben 2023). AES “represent the most direct instrument for delivering environmental benefits on agricultural land” and “are funded under the European Agricultural Fund for Rural Development (EAFRD) regulation” (Prager 2015, p. 59). For further information, see: EU Regulation 1305/2013, art 28 (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R1305 – last accessed 27 March 2026).

[7] Agri-environmental measures are developed at EU, national, regional, or local levels to ensure they can be tailored to the wide variation in farming systems and environmental conditions across the EU (Bazzan et al. 2023).

[8] This does not imply that AEMs were introduced in the Netherlands only at that time. Since 1981, the Dutch government has provided subsidies for agri-environmental management to conserve nature and landscape values in agricultural areas (CLO 2025b).

[9] That is: the focus has been on the conservation or restoration of 68 species protected under the Birds and Habitats Directive, that (also) inhabit agricultural areas (CLO 2025b). Most of these target species are birds, including the black-tailed godwit, lapwing, and skylark, but they also comprise several species of fish, amphibians, mammals, and insects (Visser and Kleyheeg 2025a).

the downward trend in several farmland bird species has slowed in areas with ANLb compared to areas without ANLb, an overall decline persists. Overall, however, ANLb in its present form is not sufficiently effective at the landscape scale; its impact at the national level remains too limited to halt the ongoing decline of agro-biodiversity. The evidence thus far seems to suggest it is not possible to reverse nationwide negative trends in meadow and arable birds, among others, on just 7% of the total agricultural area. However, Visser and Kleyheeg (2025a) conclude that populations of target species can stabilize or even increase when intensive ANLb management is implemented across larger, contiguous areas. In their view, this strongly indicates that the ANLb can potentially reverse the declining trends of the species concerned, provided that sufficiently intensive AEMs are spatially clustered.[10]

These findings underscore that the effectiveness of ANLb ultimately depends on how it is institutionally governed and implemented across space. ANLb aims to achieve more effective and efficient agricultural nature and landscape management (potentially resulting in greater ecological benefits) while promoting shared regional responsibility. Self-governance is the guiding principle in this system (the idea is that this will increase commitment, support and the effort people put in), and farmers participate on a voluntary basis. However, the government is by no means absent; it is responsible for financing ANLb and ensuring that agreements are upheld (van Dorp and Wieringa 2024).

4 Structure, functioning, and farmer participation in collectives

Currently, a total of 39 farmer collectives exist in the Netherlands. Together, they comprise more than 600 staff members and board representatives, and operate as independent organizations — predominantly cooperatives — with their own governing boards and operational structures. Members of these collectives consist mainly of Dutch farmers, alongside a small proportion of private landowners[11], who implement AEMs under the ANLb-scheme (BoerenNatuur, n.d.). They are, in effect, the participants in the AES. The number of farmers affiliated with a collective varies widely, ranging from fewer than 100 to more than 1,300 (‘Agrarisch Natuurbeheer voor Beginners’ 2025).

Within the ANLb, the farmer collectives develop nature conservation strategies and prepare so-called ‘area-based applications’ in accordance with provincial nature management plans. As coordinating organisations, the collectives submit these applications to the provincial authorities in order to obtain funding for the implementation of AEMs within designated areas. This application applies to all participating members of the collective (RVO, n.d.).

[10] The distinction between ‘light’ and ‘intensive’ AEMs concerns the extent to which these measures interfere with regular farming operations. Intensive AEMs entails more substantial adjustments to farm management than light AEMs.

[11] Farmers are agricultural producers who use land for farming activities, whereas private landowners are individuals who own land but do not necessarily use it for agricultural production.

By organizing farmers within specific geographic regions, these collectives embody a 'spatial targeting' approach to align conservation efforts with ecological processes, thereby increasing their spatial effectiveness. This enables farmland nature management to better match the spatial scale of priority habitats, water systems, and landscape elements such as ditches, rows of trees, and hedgerows (Westerink et al. 2017; Polman and Jongeneel 2020). Farmers can only participate if their parcels are located within designated habitat areas and if they meet the specific requirements set by the collective. Consequently, the ANLb-scheme targets areas where coordinated management is expected to yield the greatest ecological benefits while ensuring that participating farmers comply with the programme's ecological and administrative criteria. Such spatial coordination is consistent with insights from metapopulation theory, which emphasizes the importance of habitat connectivity for species dispersal and long-term population persistence (Hanski 1998).

Farmers can only receive ANLb-funding as participants in a farmer collective. To do so, they must enter into a contractual agreement with a collective, typically for a fixed period of six years. Within this agreement, the farmer and the collective determine how the AEMs will be implemented on the farm. Although participation is voluntary, these AEM commitments are formal, as farmers agree to multi-year management contracts (BoerenNatuur, n.d.). The specific conditions and calls for ANLb funding differ between provinces; the Netherlands consists of twelve provinces, each responsible for implementing the scheme within its territory and determining regional priorities for farmland nature management (RVO, n.d.).

In addition to informing and motivating farmers to participate in the ANLb during meetings and outreach activities, field officers of the collective also engage directly with farmers through on-farm consultations.[12] During these discussions, they assess which AEMs can be implemented on farmers' land in specific high-potential areas to improve habitat suitability for locally occurring species, after which tailored agreements are made with the farmers involved. In this respect, field officers select AEMs that address the four fundamental ecological requirements shared by animal species, namely food, safety, reproduction, and connectivity (i.e., the capacity of species to move through the landscape) (BoerenNatuur, n.d.). These AEMs focus mainly on actively improving biodiversity in agricultural areas (i.e., taking action) rather than merely reducing the negative impacts of agriculture (i.e., refraining from certain activities). Examples include the creation of wet grassland areas, species-rich grasslands, and winter food fields (Westenburg 2025). Many of the management measures required to protect these species demand additional effort from farmers. The ANLb — funded jointly by the European Union and the Dutch provinces — provides fixed, individual payments to compensate farmers for costs incurred and revenue fore-

[12] Sometimes farmers also join a farmer collective on the recommendation of a supply chain partner in order to qualify for the payments associated with, for example, a green certification label.

gone when implementing these measures, regardless of the actual ecological results (Thiermann et al. 2023; Splinter and Dries 2025).[13]

Grassland, covering more than 50% of agricultural land, is the dominant land use in the Netherlands and is used primarily for dairy farming (CLO 2025c). Of this area, 323,000 hectares has been designated as a so-called 'target area' within which farmers can enter into agri-environmental management agreements. In practice, during the current ANLb programme period (2023–2028), grassland management contracts have been concluded for approximately 87,000 hectares (Woltjer et al. 2025). The majority of this area is located in the northern provinces of Friesland and Noord-Holland. These provinces contain most of the Netherlands' key meadow bird areas, and AEMs for the protection of grassland-breeding waders has consistently accounted for the largest share of agri-environmental management (CLO 2025b).

Although the ANLb has improved the feasibility and targeting of farmland nature management (Boonstra et al. 2021; Splinter and Dries 2025), evidence suggests that it has not substantially increased the average spatial concentration of measures. Only a slight increase has been observed in the clustering of intensive meadow bird measures (Visser and Kleyheeg 2025a). This is notable given the importance of spatial clustering for ecological effectiveness, as discussed in Sect. 3. In particular, the likelihood of positive population trends increases when a larger share of an area is managed under intensive AEMs (see also Visser and Kleyheeg 2025b).

Partly in response to these findings, the financial resources allocated to the ANLb have increased substantially. The annual budget, which amounted to €80 million in 2020, has risen to approximately €120 million in recent years. From 2026 onwards, funding for farmland conservation will be expanded stepwise, reaching an additional €500 million per year by 2030 (Ministry of LVVN 2024). This increase reflects growing recognition that continuation of the scheme at its previous scale would be insufficient to achieve meaningful biodiversity recovery. Additional funding is expected to enable a substantial expansion of the area under agri-environmental management to around 280,000 hectares (Agrarisch Natuurbeheer voor Beginners, 2025). Policy efforts also aim to shift the focus towards more intensive management measures,

[13] Although payments are not dependent on achieved ecological results, monitoring is actively carried out by the provinces and farmer collectives. By establishing and implementing habitat-focused monitoring, the collectives not only measure the effect of the ANLb on the target species but also determine what other effects the ANLb achieves. By systematically collecting data, farmers and collectives can learn, evaluate, and manage more effectively (BoerenNatuur, n.d.). Governments, in turn, can compare the development and distribution of animals in areas where AEMs are implemented with areas where it is not. Specialized species organizations — such as SOVON, that monitors breeding, migratory and wintering birds — and volunteers collect a large portion of these policy monitoring data (Bij12, n.d.). Moreover, the government checks weekly, using satellite images, whether the parcels with ANLb subsidies comply with the established requirements (RVO, n.d.).

rather than relying predominantly on relatively low-threshold interventions such as nest protection.[14]

At the same time, approximately one quarter of Dutch farmers currently participate in the ANLb, indicating that further gains could be achieved by increasing farmer participation. Farmer collectives play a key role in motivating farmers to participate in ANLb (Dik et al. 2023); however, understanding farmers' drivers to participate is equally crucial for improving the effectiveness of the scheme. In general, farmers' participation in the ANLb-scheme is shaped by a combination of intrinsic motivations, financial considerations, and practical constraints. Research shows that intrinsic motivation to protect nature and biodiversity is often the most important driver for farmers who participate in agricultural nature management (Runhaar et al. 2020; see also Kuhfuss et al. 2022). Although financial compensation for AEMs plays a facilitating role, it rarely covers all costs. Consequently, farmer participation in collective AES has been shown to be only partly driven by economic considerations (Barghusen et al. 2021).

Practical factors related to farm management — such as the compatibility of measures with existing production systems, time availability, and administrative requirements — are frequently cited barriers to participation. In particular, non-participating farmers often report that ANLb measures do not fit well within their farm operations or create additional bureaucracy (Runhaar et al. 2020). To illustrate: an average dairy farm can implement intensive AEMs on a maximum of about 20% of its land. The lower-quality roughage produced on these biodiversity friendly managed parcels can be integrated into the farm system up to this level; for instance as feed for dry cows and young stock. However, when the share of intensive AEMs exceeds this threshold, milk production begins to decline. These effects on farm operations are not compensated by the current payment rates for the intensive AEMs (de Jong 2025).

Social influences from actors in the farmers' environment, including neighboring farmers, advisors, citizens, and policymakers, can encourage participation by providing knowledge, practical support, or peer pressure. The desire to be recognized as a 'good farmer' may further motivate farmers to engage in ANLb (Barghusen et al. 2021; Schneider 2021; Sander et al. 2024). These social dynamics are often facilitated and reinforced through institutional arrangements within the farming community. Farmer collectives play an important role by acting as knowledge exchange and learning platforms, thereby strengthening social capital among stakeholders (Barghusen et al. 2022). Despite these influences and institutional support, participation remains largely voluntary and individually motivated, although greater societal appreciation of farmers' conservation efforts could stimulate broader uptake of ANLb

[14] Farmers can choose from a range of measures to protect meadow birds, and it appears that they mainly opt for nest protection, because it can be easily integrated into the existing farm management system (Algemene Rekenkamer 2021). For example, farmers indicate the locations of meadow bird nests on their land to avoid driving over them with tractors. However, this measure provides limited benefits for species such as the black-tailed godwit. What benefits the godwit more is increasing soil moisture in grasslands by raising the ground water level and creating shallow ditches that retain water. Yet, farmers rarely choose these more intensive measures: they are more demanding because of their higher level of complexity and stricter requirements. Moreover, intensive AEMs require more time, knowledge, and often adjustments to farm management practices.

measures (Runhaar et al. 2020). Ultimately, the effectiveness and expansion of the ANLb depends not only on financial resources and policy design, but also on the ability of farmer collectives to mobilize and sustain farmer participation over time.

5 Financing mechanisms for agro-biodiversity

The Dutch approach of farmer collectives can fundamentally be characterized as a bottom-up process that helps guiding and coordinating farmers' land management towards nature-inclusive farming. A key advantage of this approach is that it reduces information asymmetries across farmers and landowners as part of a collective. That is, collectives allow for information sharing of experiences and practices between and across farmers in the collectives. This is especially important when land management decisions require coordination of nature-inclusive farming practices that foster spatial contiguity of land use, which is key in protecting and enhancing biodiversity.

Promoting spatial coordination of land use is a formidable challenge for cost-effective design of Payment for Ecosystem Services (PES) schemes (e.g., Engel et al. 2008). In the EU and elsewhere, conservation efforts have predominantly been focused on private landowners, as valuable ecosystem services and biodiversity are frequently found on privately-owned land. However, investing in enhancing these ecosystem services is costly for farmers. Governments (regulators), the usual 'buyers' of ecosystem services, face difficulty in fully knowing how these costs are distributed among farmers. Additionally, monitoring the actions of farmers under contracts aimed at strengthening the supply of ecosystem services is also costly and complex. Beyond these cost differences, environmental benefits and the amount of ecosystem services from land use also vary spatially. The combined variation of costs and benefits across space, alongside the information asymmetries between regulatory agencies and landowners, make it difficult for policymakers to maximize the environmental returns from given limited public funds. This challenge is compounded by issues like adverse selection and moral hazard, which hinder cost-effective effective policy design (Hajkowicz et al. 2007; Ferraro 2008; Fraser 2009; White and Sadler 2012).

As a consequence, AES have often neglected to explicitly consider the spatial coordination of landowner participation (e.g., Wünscher et al. 2008) and frequently taken the form of allowing farmers to voluntarily enroll in return for receiving fixed payments for land management actions irregardless of the spatial heterogeneity and distribution of costs and benefits (e.g., Hanley et al. 2012). Due to this, such fixed subsidy payments are often not cost-effective, as some farmers are likely to be over-compensated and fail to target the farmers who can provide the greatest amount of ecosystem services.

Farmer collectives are likely to mitigate these concerns and, in theory, can promise a more cost-effective solution compared to fixed PES schemes. This is because collectives have the ability to reduce information asymmetries due to the cooperative nature of such an approach. In a non-collective French AES, Kuhfuss et al. (2016) find evidence that encouraging farmers through 'nudges' — such as sharing information about their peers' pro-environmental farm and land use practices — promotes sustained conservation efforts beyond the end of the AES contract period. There is also a body of experimental evidence showing the potential of information provision and sharing to enable more informed decision-making within agri-environmental contexts, especially when the opportunity costs of land use are heterogeneous across farmers (e.g., Palm-Forster et al. 2018; Wu et al. 2021).

These empirical findings are encouraging in view of the permanence of farmer collectives where information sharing is internalized by design. That is, farmer collectives have the potential to increase conservation benefits by aligning the underlying incentive program in a way that internalizes the spatial synergies through the 'clustering' of participating farmers in designated areas. This feature is something which a more 'top-down' AES design like the aforementioned fixed subsidy payment schemes inherently lack. One proposed solution to enhance spatial coordination and agglomeration under such fixed payment schemes is the agglomeration bonus: farmers receive an additional payment when their neighbors also participate, encouraging communication about each other's intentions (Parkhurst et al. 2002; Drechsler et al. 2010; Banerjee et al. 2014; Wätzold and Drechsler 2014). This mechanism offers a two-part payment structure to address spatial variability in ecological potential. A uniform payment is provided to those farmers who adopt biodiversity-friendly land use practices, while an additional bonus is offered to those who enroll adjacent parcels of land being offered for enrollment by neighboring farmers. The collective AES in the Netherlands, with its more participatory approach, differs from schemes that rely on this agglomeration bonus to tackle spatial coordination (Barghusen et al. 2021).

Yet achieving this coordination among farmers is challenging. There is well-documented evidence that an agglomeration bonus scheme can create coordination problems due to the possibility of multiple Nash equilibria, making it difficult to determine the optimal arrangement of farmers and unable to exploit the spatial synergies across land (Parkhurst et al. 2002; Parkhurst and Shogren 2007, 2008; Banerjee et al. 2014). Additionally, transaction costs involved in implementing an agglomeration bonus scheme can be significant, potentially reducing uptake and undermining its effectiveness (Banerjee et al. 2017). Also in this respect, since a farmer collective is built on cooperation, it can help promote and solve the spatial coordination problem amongst farmers, lowering transaction costs and improving cost-effectiveness. Huber et al. (2021) report a case study in Switzerland showing how a collaborative bottom-up approach involving a range of stakeholders (farmers, farm advisors and the local community) to setting up an agglomeration bonus scheme can improve spatial connectivity of land parcels which is conducive to biodiversity conservation. The authors show that farmers' conservation costs are a key factor in enrolling parcels in the scheme.

Extending this line of research, the potential of using farmer collectives as an information sharing platform to optimally align agglomeration subsidies to farmers' opportunity costs of land use is a promising avenue to explore. A casual observation and interpretation of this might suggest that complementing top-down subsidy schemes with spatially coordinated, bottom-up farmer collectives could provide a more efficient use of public funds than arbitrary (ad hoc) uniform agglomeration payments. The recent study by Reichenspurner et al. (2023) on the Dutch farmer collectives provides a solid basis for exploring this conjecture; they find that, although the overall experience among farmers participating and cooperating in the scheme is positive, significant improvements to scheme design are needed to better leverage farmers' knowledge and experiences. This would facilitate a more efficient fund allocation to maximize the ecological potential across the landscape.

6 Concluding remarks and prospect

Since many problems related to the protection and sustainable use of (agro-)biodiversity have a strong spatial component, considerations of spatial scale and level are crucial for analyzing these issues. However, geographical approaches have traditionally focused more on spatial patterns than on the underlying ecological processes, which can limit a full understanding and prediction of the effects of biodiversity loss. While the interdisciplinary field of landscape ecology integrates geography with an ecological analysis of spatial patterns, no equivalent geographical field comprehensively combines ecology and economics.

As we advance in our understanding of environmental systems, the integration of biodiversity into geographical science presents both significant challenges and valuable opportunities. Biodiversity, once viewed as a separate concern within environmental science, is now increasingly recognized as a core component of so-called 'integrated landscape approaches' to achieving conservation objectives (Langston et al. 2025). By better understanding the spatial distribution and ecological processes that sustain species, biodiversity can more effectively be incorporated in geographical models to inform and design policy, land-use planning, and nature conservation strategies.

Pursuing an integrated landscape outlook, the key lesson lies in the ability to adopt interdisciplinary approaches that bridge ecological, economic, and spatial data. Geographers are in a unique position to shape the future of biodiversity conservation by developing models that consider the spatial variability of ecosystems, the impacts of human activity on biodiversity hotspots, and the feedback loops between ecological health and socio-economic factors. This integration calls for new tools and frameworks that combine geographic information systems (GIS), remote sensing technologies, and ecosystem service valuation methods. Future research could also explore how integrating biodiversity into spatial planning can lead to more nature-inclusive (rural) landscapes where nature protection and agricultural production coexist.

However, the integration of biodiversity into geographical science is not merely an academic exercise but also a critical step towards sustainable rural planning, especially in a densely populated country like the Netherlands. Here, the past has shown that an AES with individual farmer participation has often been ineffective in enhancing biodiversity, mainly due to its limited capacity to provide effective incentives to spatially coordinate land use management strategies at the landscape scale.

Since 2016, however, the governance of these schemes has been reorganized through the establishment of 39 farmer collectives. These legally recognized associations enable farmers and other private landowners to participate jointly in AEM programmes. The collectives receive public funding to coordinate the implementation of measures within designated regions, thereby aligning farm-level management with area-specific biodiversity objectives and facilitating a more spatially coherent approach.

Against this background, the key question is how farmer collectives influence the effectiveness of top-down schemes in improving biodiversity at the landscape level, particularly through spatial coordination in land use. The findings suggest that farmer collectives constitute a crucial institutional mechanism for addressing this challenge, although their potential has not yet been fully exploited.

From an ecological perspective, biodiversity outcomes depend strongly on spatial configuration, including habitat size, connectivity, and the clustering of management efforts. This implies that isolated, farm-level interventions are insufficient to deliver adequate biodiversity gains. Instead, coordinated action across farms is required. Farmer collectives contribute to this by aligning individual land-use decisions, facilitating landscape-scale planning, and internalizing spatial externalities that would otherwise remain unaddressed. In this sense, they effectively bridge the gap between top-down policy design and local, bottom-up implementation.

At the same time, the empirical evidence indicates that current levels of spatial coordination remain limited. Despite improvements in feasibility and targeting, the ANLb has not substantially increased the spatial concentration of measures, which constrains its ecological effectiveness at the national scale. This reveals a critical 'implementation gap': while the institutional design of collectives is well-suited to foster coordination, achieving sufficient scale and intensity of participation in practice remains challenging. This gap largely stems from economic and behavioral factors. Farmer participation is voluntary and shaped by a combination of intrinsic motivations, financial incentives, and practical constraints. Moreover, existing financing mechanisms do not fully account for spatial heterogeneity in costs and ecological benefits, limiting their ability to incentivize coordinated participation where it matters most. Although farmer collectives help reduce information asymmetries and transaction costs, further refinement of policy instruments is needed to better align incentives with spatial ecological objectives.

These findings suggest that farmer collectives enhance the effectiveness of top-down AES primarily by enabling spatial coordination, but only when sufficient participation, appropriate incentives, and supportive governance structures are in place. Strengthening these conditions — through increased funding, improved targeting, and adaptive, spatially informed financing mechanisms — is essential to unlock the full potential of collectives. Promoting landscape-level biodiversity requires institutional innovation in conjunction with a deeper integration of ecological, economic, and spatial considerations across policy design and implementation.

Farmer collectives exemplify how explicit collaboration can enhance spatial coordination of land use decisions and improve biodiversity outcomes. Centering biodiversity within geographical science enriches the discipline itself while fostering sustainable and biodiverse landscapes in the long term, and can provide collectives with deeper insights into the ecological values of different areas and the (potential) impact of management measures. This can lead to more effective and efficient strategies for nature conservation at the landscape level.

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