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Opinion

Rethinking agri-environmental schemes for a greener Europe

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Agriculture covers nearly 40% of European Union (EU) land, making farming practices central to biodiversity conservation and climate goals. Agri-environmental schemes (AES)—voluntary incentives under the EU's Common Agricultural Policy—have received billions in public funding, yet farmland biodiversity continues to decline and environmental targets remain largely unmet. Drawing on multiscale empirical research across five European case studies, we identify key systemic barriers to AES effectiveness: insufficient spatial targeting, inflexible contract design, bureaucratic burden, inadequate advisory support, and weak monitoring. In this opinion article, we argue that a fundamental overhaul is needed and propose an adaptive, multiscale policy framework that integrates bottom-up co-design with farmers, spatially explicit environmental goals, and evidence-based monitoring to deliver measurable ecological outcomes across Europe.

Significance

Despite major investments in agri-environmental schemes, Europe's farmland biodiversity continues to decline. This opinion article identifies the systemic barriers preventing these policies from delivering results and proposes a concrete, evidence-based framework for reform. As the European Union revises its Common Agricultural Policy, our findings offer timely, actionable guidance for policymakers, farmers, and conservation practitioners. By shifting toward adaptive, spatially targeted, and co-designed schemes, Europe can better align agricultural policy with its biodiversity and climate commitments.

The policy framework shaping Europe's farmland

With nearly 40% of the land in the European Union (EU) dedicated to agriculture, how farming is conducted has a decisive influence on biodiversity conservation and climate mitigation [1]. Recognizing this, the European Green Deal—particularly the Farm to Fork Strategy and the Regulation on Nature Restoration—seeks to align agricultural policies with broader environmental policy objectives.

The Common Agricultural Policy (CAP) is the primary driver of agricultural practices in the EU, shaping land management decisions through subsidies and regulatory frameworks. Among its key instruments are agri-environment-climate measures, often termed agri-environmental schemes (AES), which incentivize farmers to adopt sustainable practices, alongside conditionality requirements.[i] AES are designed to support 'farmers and other land managers who undertake, on a voluntary basis, management commitments that contribute to climate change mitigation and adaptation and to the protection and improvement of the environment including water quality and quantity, air quality, soil, biodiversity and ecosystem services'.[i] Specific AES are developed by the Member States and can be implemented through top-down or locally led initiatives.

Despite substantial investments—€17.2 billion allocated under Measure 10 of the European Agricultural Fund for Rural Development between 2014 and 2022—biodiversity in the EU continues to decline [2,3], and climate and environmental targets remain largely unmet [4–6]. While concerns about the effectiveness of AES and low levels of farmer participation are well documented [7,8], the systemic barriers to their success, shaped by complex interactions between policy design, farm-level decision-making, and local contexts, remain poorly understood. This gap exists partly because many analyses are either confined to individual case studies or are produced by high-level working groups (expert panels or researchers) that focus on specific issues such as payment design, biodiversity monitoring frameworks, or farmer

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participation rates, thereby making their findings less generalizable and preventing them from capturing the full complexity of these interactions.

As part of the Horizon 2020 project BESTMAP (Behavioral, Ecological and Socio-economic Tools for Modeling Agricultural Policy) [9], we identified key factors underlying the persistent shortcomings of AES through farmer interviews, mixed-methods, and modeling approaches across multiple scales (Boxes 1–5), including three EU countries (Czechia, Germany, and Spain), with two additional case studies in the United Kingdom and Serbia providing comparative insights. These regions differ substantially in their environmental conditions, farm structures, and historical legacies, including the influence of socialist agricultural systems in Czechia and eastern Germany, thereby enabling us to identify both universal barriers to AES success and context-specific factors that shape their effectiveness (Box 1). Drawing on findings from BESTMAP[ii] and complementary research, this opinion article explores the main obstacles to AES success and offers recommendations for improving the EU's agricultural policy framework.

Why do AES fail to reach their targets?

The spatio-temporal scale and scope of AES implementation are insufficient

AES have long been a cornerstone of EU agricultural policy, designed to enhance biodiversity and ecosystem services. However, their ecological effectiveness has been widely debated, with empirical studies showing mixed results, indicating that a substantial proportion of AES fail to produce measurable improvements in biodiversity [31–34]. Despite their goal of maintaining and restoring farmland biodiversity across Europe, the ecological impacts of these measures are hard to generalize [35], largely because their effectiveness depends strongly on specific environmental and contextual factors [36]. This pronounced 'context dependency' is one of the reasons why AES do not consistently deliver the intended outcomes.

One major constraint is the limited spatial extent of AES implementation. Ecological benefits of AES are often modest because the total area covered by these measures is too small to generate meaningful population-level effects. For example, species distribution models of farmland birds in our German case study revealed that while AES improved habitat suitability for most species, the gains were minimal when current implementation levels were compared with a scenario without AES [16]. However, expanding the overall area under AES improved landscape-level habitat suitability, highlighting that limited coverage of AES is a critical barrier to their success. Similar findings emerge from other studies modeling farmland bird population trends across the EU [37], their abundance [38] and population growth rates [39] in the UK, and species richness of both birds and butterflies [40] in Switzerland, all of which show higher biodiversity levels associated with larger AES areas.

Another key limitation is that the spatial focus of AES is often too localized, failing to account for the landscape-level coordination needed to effectively support biodiversity [41]. Indeed, the spatial scale at which AES generate ecological benefits varies by measure type and landscape context [16,36]. For instance, in our German case study, grassland-focused AES had positive effects on farmland bird habitat suitability primarily at the specific locations where they were implemented [16]. In contrast, measures targeting arable land showed positive impacts only at larger spatial scales [16], likely reflecting cumulative effects of multiple measures enhancing habitat connectivity and/or resource complementation across the region. By emphasizing small-scale measures, current AES policy therefore often falls short of delivering landscape-level biodiversity outcomes.

Finally, the design of AES often fails to account for the ecological and socio-economic context in which AES are implemented, particularly given the time required for ecological benefits to

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materialize. Interviews with farmers (Box 2) indicate that AES could be designed and implemented more effectively, particularly with respect to contract duration [19]. For example, in Czechia, farmers' willingness to participate in AES was strongly influenced by contract length [20]. For

Box 1. BESTMAP's multiscale approach: from regional case studies to European-level outputs

The BESTMAP project developed fine-scale biophysical and socio-economic models for five European case study regions (Figure I), namely the Mulde River basin in Germany, South Moravia in Czechia, Catalonia in Spain, the Humber catchment in the UK, and the Bačka region in Serbia [10]. These regions present large differences in climatic, topographic and soil conditions, as well as in the predominant crops, agricultural systems, and historical contexts, including the legacy of socialist agriculture in Czechia and eastern Germany [11]. This diversity enables us to distinguish between universal systemic barriers to the effectiveness of AES and region-specific factors, thus strengthening both the representativeness and the nuance of the project's findings. The representativeness of the case studies for the rest of Europe was assessed by developing transferability maps showing the transferability potential of BESTMAP models to other Nomenclature of Territorial Units for Statistics level 3 (NUTS3) regions across Europe [12]. For each region, the project collated detailed geospatial information, including the IACS data, which provide information on the location and characteristics of each agricultural parcel, the crop grown, and the AES implemented [13]. The IACS data were crucial for many of the analyses carried out in the project. For example, the spatial location of AES in relation to environmental factors and farm characteristics was investigated in two of the study regions, revealing that AES are often placed in marginal, unproductive fields within the farm, and that small farms are less likely to participate in AES [14,15]. Information on AES adoption was also used in the biophysical models (described in Box 4) to estimate AES effects on biodiversity and ecosystem services [10]. The outputs of these models were aggregated to the farm level and upscaled to the European level through meta-models, using data from the Farm Accountancy Data Network (FADN) [18]. These Europe-wide outputs help in generalizing the project's findings beyond the case study boundaries, while the transferability analysis provides information on the 'spatial boundaries' within which such outputs are credible.

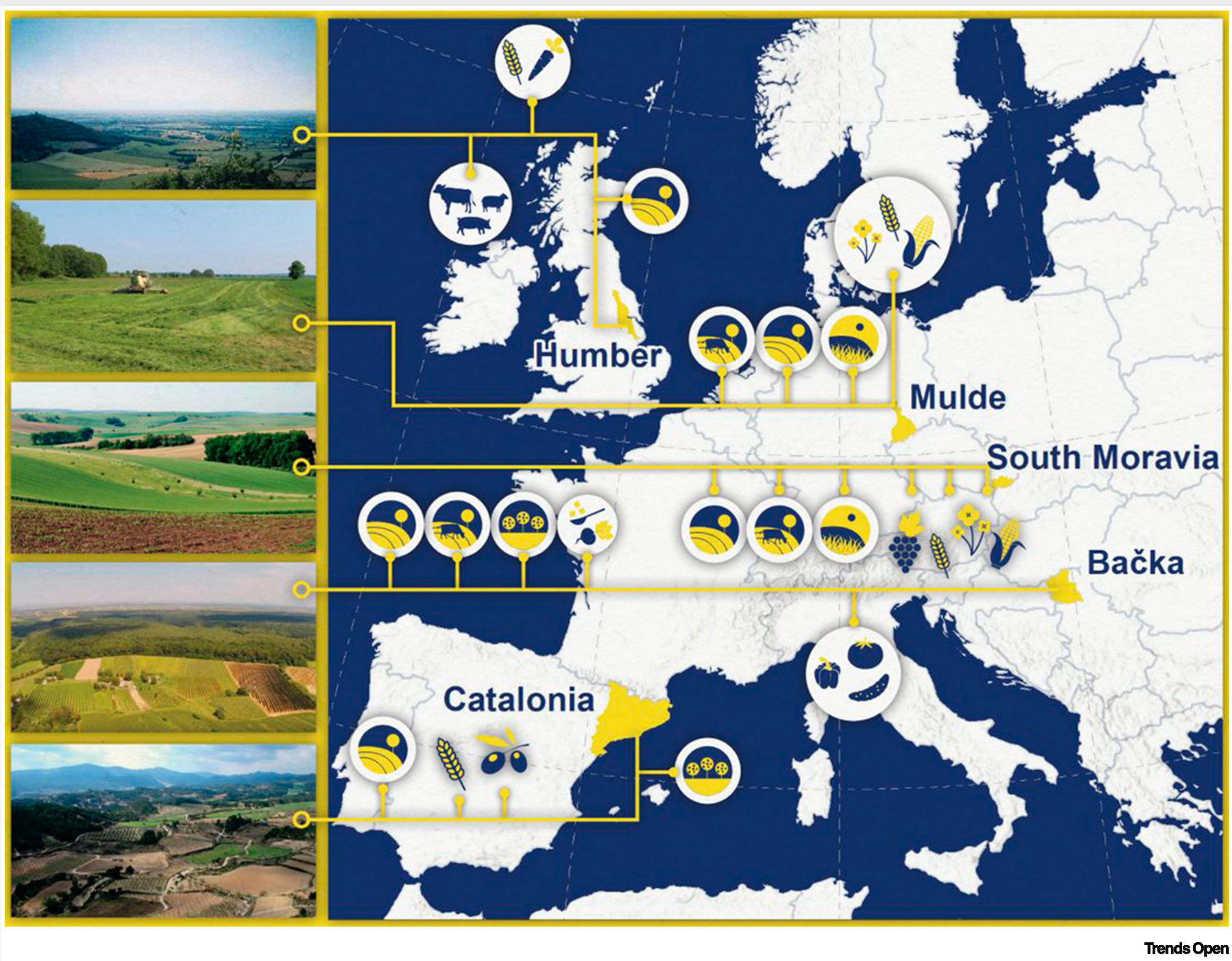

Figure I. Five European case-study regions within the BESTMAP project. The figure was produced in Adobe Illustrator.

Box 2. A mixed-methods approach to farmer data collection

In all BESTMAP case studies, a two-stage methodological approach was applied to gather comprehensive insights into farmers' decision-making regarding AES. First, semistructured interviews were conducted with 124 farmers, following a common protocol of open-ended questions designed to elicit qualitative data on farmers' backgrounds, attitudes, ecological reflections, and motivations for AES participation [11,19–21]. These interviews were transcribed and analyzed using qualitative content analysis supported by computer-assisted software, with coding frames developed both deductively and inductively to systematically interpret the data. The sampling strategy ensured coverage of diverse farmer profiles and environmental strata, aiming to capture the heterogeneity of the farming population. In the second phase, an online questionnaire was distributed to farmers, including a discrete choice experiment to quantitatively assess preferences for different AES contract attributes such as payment level, contract length, bureaucratic effort, and advisory support [22,23]. This survey yielded 381 responses across four case studies (Czechia, Germany, Serbia, and the UK) [23]. This mixed-methods data collection enabled us to 'look into a farmer's head' (Figure I) and obtain qualitative and quantitative data for a robust understanding of farmer behavior and preferences regarding AES.

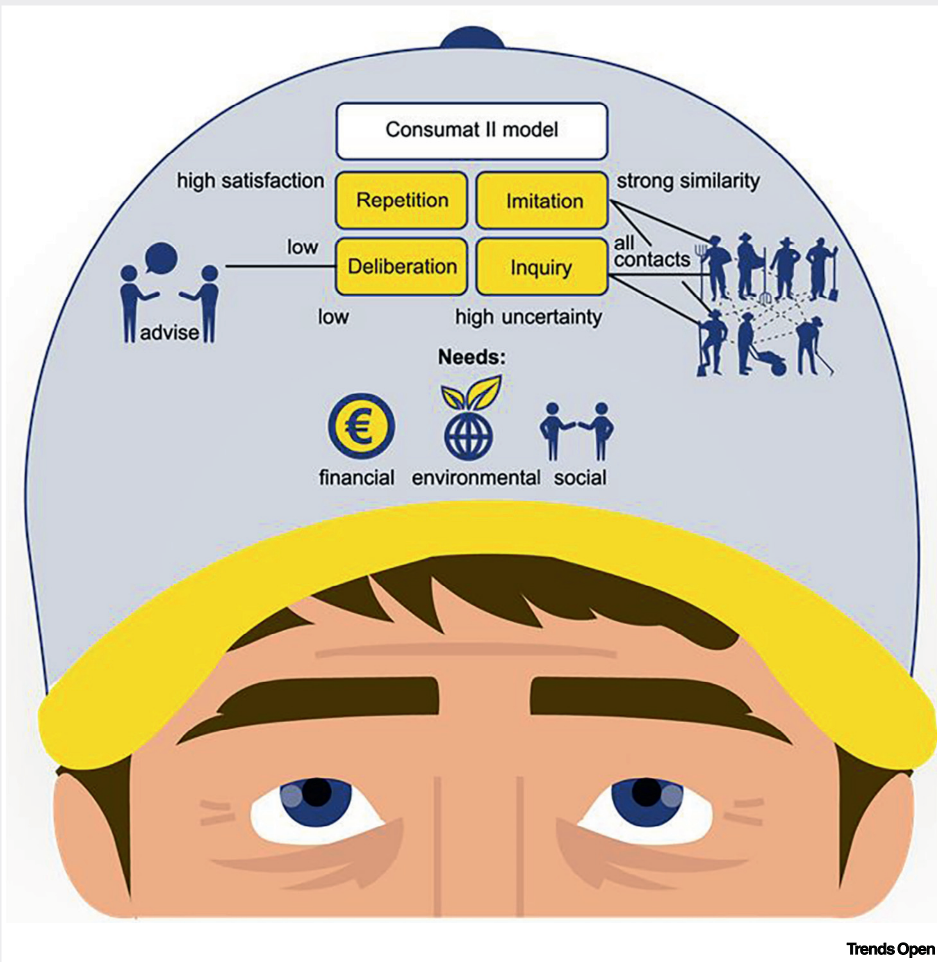

Figure I. A mixed-methods approach to obtain an understanding of farmers' behavior and preferences regarding AES. The figure was produced in Adobe Illustrator.

permanent grassland measures, farmers tended to prefer longer contracts, while for measures on arable land, they favored shorter or more flexible agreements. Long-term measures were generally preferred when farmers had long-term tenancy agreements, because about 80% of farmland is rented, and only 20% is owned by farmers in this case study. This misalignment between the design of AES and the environmental or socio-economic context ultimately constrains their potential success.

Box 3. An archetype-based approach to agri-environmental analysis and policy targeting

The BESTMAP project employed an innovative archetype-based methodological approach to both analyze agri-environmental potential across Europe [24] and to identify FSAs that help explain the uptake of AES in the case studies [25]. At the continental scale, a novel, fully data-driven spatial classification was developed using machine-learning clustering of 17 bioclimatic, soil, and topographic variables, resulting in archetypes of agri-environmental potential that are both scalable and flexible [24]. This approach uniquely integrates up-to-date biophysical data and reduces subjectivity, enabling spatial targeting of agricultural policies at various scales, from the European continent to regional landscapes. Complementing this, the FSA analysis focused on nearly 8000 farms in Czechia, Germany, and the UK, utilizing detailed, spatially explicit data from the IACS [25,26]. This allowed the creation of a simplified yet robust typology of farming systems based on two key structural dimensions—farm specialization and economic size—derived from field-level data. Farms were classified into 20 archetypes, each representing a unique combination of these dimensions, enabling the identification of groups of farms (Figure I) likely to respond similarly to agricultural policy instruments, such as AES. This archetype-based approach was able to link spatially explicit, large-scale environmental potential with farm-level structural diversity, providing both a generalizable framework for policy design and a practical tool for understanding and predicting the adoption of AES across diverse European farming contexts [11].

Figure I. FSAs used to explain the uptake of AES in European case studies. The figure was produced in Adobe Illustrator.

Box 4. Biophysical and socio-economic modeling of AES impacts

The BESTMAP project investigated the impact of AES on biodiversity and ecosystem services by developing and adapting four biophysical models and one socio-economic model for their application to the project's study regions [10]. The models were specifically designed to estimate the effects of different types of AES in a spatially explicit way, thus producing output maps for different AES adoption scenarios. The biodiversity model, based on ensemble species distribution models, produces maps of habitat suitability for selected farmland bird species and investigates relationships between species occurrences and AES adoption [16]. The food and fodder model estimates how AES adoption affects the yield and production area of selected agricultural crops, as well as the farm's (or field's) economic output (in €). The carbon sequestration model combines information on soil characteristics, climatic conditions, crops, and AES to estimate soil organic carbon content (in t/ha). The water quality model is based on the InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) nutrient delivery ratio model, adapted to include AES effects, and returns maps of nutrient loads for nitrogen and phosphorus (in kg/ha/year) [17]. Finally, the socio-economic model estimates the percent change in estimated Farm Net Value Added for a given year, per farm, between AES adoption and no-adoption scenarios.

Box 5. Agent-based modeling of AES adoption

Agent-based models (ABMs) were developed for each BESTMAP case study to simulate and analyze how individual farmers decide to adopt and spatially allocate AES under varying policy scenarios [27]. The primary goal of these models was to assess the impact of different contract characteristics—such as duration, advisory support, administrative effort, and payment level—on the uptake of key AES [23]. Each case study ABM was built using a structured, three-step decision-making framework: first, determining a farmer's openness to specific AES based on personal experience, advisory support, and social influence; second, selecting suitable fields for AES adoption by considering their biophysical characteristics; and third, conducting an economic deliberation to decide on adoption based on expected versus offered payment levels. To capture farmer diversity [28], the models incorporated the FSA classification, though the ability to parameterize behavioral differences was limited by the available survey data. In addition to the case study models, BESTMAP also developed an ABM at the European scale, which differs by integrating outputs from a statistical analysis of the EU-wide FADN [29]. This European ABM clusters farms by FSA using predicted adoption probabilities to simulate AES uptake across 28 EU countries. The European ABM provides a broader, harmonized perspective on policy impacts and adoption patterns, enabling scenario analysis and upscaling of findings to inform EU-level agri-environmental policy design [23,30].

AES lack spatial targeting across scales

Achieving the EU's conservation objectives requires a systematic approach to identifying areas prioritized for biodiversity protection in agricultural landscapes across spatial scales [42–44]. A continental-scale analysis of AES spending highlighted a mismatch between spending allocation and areas of greatest conservation need [45]. While most agri-environmental interventions are tailored to regional conditions, the majority of existing top-down approaches lack spatial targeting within those regions. AES allocation frequently fails to align with priority areas for biodiversity conservation and environmental impact reduction [45–47] or the delivery of ecosystem services [48]. The design and implementation of AES further fail to capture the diverse agricultural and ecological conditions that are crucial for their long-term effectiveness. Moreover, AES mostly focus on single species or ecosystem services, neglecting trade-offs between taxa or services [49] and overlooking cross-scale effects of implemented AES. Our models revealed that the impact of AES is highly dependent on both spatial scale and species, with context-specific factors, such as landscape complexity, influencing their effectiveness [16,36]. These factors should therefore be carefully considered when determining the spatial allocation of measures.

Not only does it matter on which farms AES are implemented, but it is also crucial to consider on which plots or fields within a farm these measures are applied. Interviews with farmers [20], as well as statistical analyses [14,15], showed that AES are typically implemented in the least productive areas of a farm, often due to poor soil quality, inaccessible terrain, or other unfavorable conditions for agriculture. While this strategy is rational from the farmer's perspective because it minimizes impacts on crop yields and farm income, it can limit the ecological effectiveness of AES and can, in some cases, even be counterproductive. For example, biodiversity-enhancing AES, such as wildflower strips for pollinator species, may turn into ecological traps when placed directly alongside roads, as traffic, noise, and light pollution can lead to higher mortality [50,51]. Rather than expecting farmers to act against their economic interests, effective policy design must harmonize ecological and economic incentives through mechanisms such as spatial targeting, results-based payments, and spatial coordination incentives, approaches that we detail below.

AES lack flexibility in implementation

The lack of flexibility of AES contracts has long been recognized as a significant barrier to their successful implementation [52,53]. Farmers frequently report that administrative constraints within AES disproportionately restrict their autonomy and professional judgement. This perceived inflexibility was a recurring theme in our discussions with farmers about AES [20]. Once enrolled in a scheme, farmers face a stringent set of rules, deadlines, cut-off dates, and reporting requirements. These rigid structures can be inappropriate for local natural conditions (e.g., weather variability or climate change-induced altered phenology) and, in some cases, force farmers to engage in practices they perceive as incompatible with good professional practice [20]. While some farmers are deterred by such an inflexible regime, others criticize its effects but accept them pragmatically. This also reflects the heterogeneity within farming communities, which needs to be taken into account in the design of effective and efficient AES [25,54]. This heterogeneity is shaped not only by farm characteristics but also by regional historical legacies; for instance, farmers in postsocialist regions often exhibit distinct attitudes toward collective action and institutional trust compared to their Western European counterparts [20]. Fixed dates, required minimum plot sizes for particular AES, and mandated minimum AES areas often contradict the flexibility farmers need to respond to changing site conditions, weather, and organizational adjustments that may arise during AES participation. From the farmers' perspective, AES requirements often appear to prioritize an administrative logic of control over professional or ecological reasoning [19].

The bureaucratic burden discourages farmers

Interviews with farmers also revealed that they are often overwhelmed by the bureaucratic demands associated with AES adoption. Many struggle to identify suitable AES that align with their existing farm management routines [19,20]. The anticipated bureaucratic burdens have also been shown to deter farmers from adopting AES altogether [55]. The problem of a high perceived administrative burden was particularly severe for small farms, which often have limited personnel to manage these requirements [19]. Indeed, interviews, as well as spatial analyses of AES adoption data from the Integrated Administration and Control System (IACS), show a preferential adoption of AES by larger farms [14,15,20,25]. This reflects the challenge faced by small farms, namely that AES adoption entails strict implementation rules, such as the minimum area that must be dedicated to a given AES [20].

The lack of advisory support tailored to individual needs limits adoption

By advisory support, we generally refer to the guidance and expertise provided to farmers by public administrations or other actors to help them understand and implement AES effectively. This support is crucial for farmers, as it facilitates the exchange of knowledge, helps navigate complex regulations, and optimizes the implementation of sustainable practices. The lack of advisory support for AES is a major issue. Studies highlight the need for better knowledge exchange between advisors, farmers, and administrators, as well as a balanced mix of incentives and regulations to improve advisory services [56,57].

Although farm advisory systems exist in all EU countries, their accessibility and breadth vary significantly [58]. For instance, among the BESTMAP case studies, advisory services were freely available to all farmers in Saxony, whereas in the UK (when still part of the EU) only farms located within Catchment Sensitive Farming areas were eligible for free advice [58]. Many farmers have lamented the inadequacy of advisory services or shown skepticism toward the agricultural policy framework, highlighting their reliance on the awareness, goodwill and support of external stakeholders. Moreover, the need for advisory support extends beyond the farmers themselves, as the farmer–landlord relationship is crucial in many European regions [20].

Limited AES funding creates frustration

Our analyses showed that AESs perceived by farmers as economically attractive, flexible, and socially rewarding tend to be oversubscribed within a given funding period. In some cases, farmers willing to participate were unable to do so because the budget for a particular scheme (e.g., flowering fallow land) was rapidly exhausted, which farmers perceived as a political failure and accordingly stated in interviews. This leads to frustration among farmers who are generally open to participating in AES [19].

Relatedly, payment levels are often perceived as rather low. Most AES options are compensated according to uniform fixed payments, based on estimated average compliance costs associated with a measure in a region or country [59]. Since they are based on average costs, they are not attractive in areas where opportunity costs are high, thus incentivizing enrollment of marginal land only (see the 'AES lack spatial targeting across scales' section above). Moreover, the payments typically do not cover transaction costs, which can be substantial given the bureaucratic burden associated with participation [60]. Accordingly, farmers expressed concerns during interviews that they can barely break even given current payment rates [20]. It is therefore crucial for policy-makers to allocate sufficient budgets to individual AES so that farmers can receive funding for measures that align well with their farming practices while also contributing to environmental targets in the specific region.

The success of AES is insufficiently monitored

Despite calls for systematic monitoring of AES since the beginning of their implementation over 30 years ago [61,62], the real-world outcomes of these measures—such as biodiversity and ecosystem service targets—are still not consistently or systematically monitored. While scattered and inconsistent monitoring approaches exist across the EU, there is no structured or standardized guidance for monitoring biodiversity outcomes [63].[iii] This lack of coordination is particularly problematic given the wide range of measures, diverse environmental conditions, and the extended time frames required for certain AES effects to become noticeable [63]. To address these challenges, a well-organized and long-term monitoring and evaluation strategy is essential. Promising examples, such as the BioMonitor4CAP[iv] and MonVia[v] projects, demonstrate the feasibility of such efforts. However, a fundamental shift is needed in the CAP monitoring framework, which currently prioritizes financial accountability over assessing ecological impacts [62,64,65].

The absence of robust monitoring data makes it impossible to accurately assess whether AES actually achieved the desired outcome, a problem known for decades. For example, in 2001, a study [61] found that AES yielded minimal benefits, with no significant improvements in species richness for insects and birds. Moreover, while it is relatively straightforward to define what sensible indicators are for the evaluation of AES that are specific in their objectives (e.g., AES tailored to conserving focal species or 'maintaining and enhancing species abundance' [66]), it is more challenging to evaluate schemes with multiple or broad objectives (e.g., creating habitats, conserving special biotopes [14]), and those targeting ecosystem services that are difficult to measure (e.g., pollination and pest control).

Understanding the environmental and agricultural management context in which AES are implemented is as critical as monitoring biodiversity itself, making ex-post evaluations of AES essential for improving policy design and implementation. However, efforts to model the impacts of AES are hindered by severe data limitations and knowledge gaps regarding specific interventions. For example, our attempts to model changes in ecosystem services triggered by AES adoption have revealed significant challenges, including a lack of standardized fine-scale, Europe-wide quantitative data on key indicators such as soil carbon, nutrient exports to watercourses, and even food production or yields [10]. Moreover, the absence of harmonized and accessible IACS data has been a major obstacle to linking AES implementation to specific environmental and agricultural conditions (but see the recent initiative of the Europe-LAND project to provide harmonized crop data from the IACS inventory [67]). Without this contextual understanding, even the best monitoring efforts will fail to provide actionable insights for improving AES effectiveness.

How to improve the effectiveness of AES

All of these reasons lead to low adoption and a limited environmental impact of AES. However, adoption rates must be interpreted against available budgets, as low uptake can result from either farmers' unwillingness to participate or insufficient government budget allocation, that is, two distinct policy failures. The barriers we identified are derived from our empirical analyses, including farmer interviews, surveys, and spatial analyses of IACS data, and represent genuine constraints on farmer participation, though budget limitations also play a role, particularly for economically attractive measures. Below, we suggest a number of options to improve AES, addressing both farmer-level barriers and systemic issues, including spatial targeting, design, advisory support, budget, and monitoring.

Spatial targeting of AES based on farm and parcel characteristics

While some form of spatial or species-specific targeting of AES exists in some Member States, it remains underdeveloped or absent in many regions. To address this in the BESTMAP project, we leveraged archetype analysis, a key methodological approach for organizing the complexity of social-ecological systems [68–70], and developed a typology of farming systems [25] (Box 3). Building on existing spatial targeting practices, this approach offers a systematic, data-driven method for spatial stratification that goes beyond traditional administrative boundaries, providing an alternative set of criteria for evaluating the suitability of specific AES [71]. Our research identified Farming System Archetypes (FSAs) based on indicators of farm specialization and economic size, which helped explain the spatial patterns of adopted AES across multiple case study areas in the EU and the UK [25]. For example, it became evident that large farms were more likely to adopt AES and implement a broader range of measures than small farms, which often face significant administrative burdens and thus focus on a narrower range of measures [14,19,20]. At the same time, higher uptake of AES was found on grazing livestock and permanent crop farms, whereas arable farms had the lowest proportion of AES adoption. These findings underline the potential of the farming system approach as a cost-effective tool for delineating the contextual factors influencing AES adoption decisions [72], including the existing differences in AES options available to different farm types (e.g., grassland vs. cropland farms). By considering the heterogeneity of farm structures, decision-makers can craft more diverse and effective measures, acknowledging that, while it is unrealistic to tailor incentives to each individual farm, grouping farms by similar characteristics can be effective [24,54]. Moreover, our insights suggest that inequalities in the availability or attractiveness of cropland- as compared to grassland-based AES should be addressed (e.g., through a fairer reallocation of CAP funds across land uses), to ensure a more equitable spread of conservation efforts in all agroecosystem types.

Consequently, the archetype approach can improve existing spatial targeting frameworks by facilitating the customization of agri-environmental policies and tailoring them to specific farming systems that are eligible for particular payment schemes or by directing specific types of AES toward particular farming contexts. For instance, small-scale farms with limited administrative capacity might be offered simplified AES with lower reporting requirements, while larger farms could be incentivized to implement more complex, multiobjective measures that require greater effort but yield higher environmental benefits. Payment levels could also be adjusted based on the economic size of the farm, ensuring fairness and encouraging participation across diverse farming systems. This targeted approach ensures that AES are not only more relevant to the specific needs and capacities of different types of farms but also more likely to achieve their intended environmental outcomes. However, fairness-related impacts associated with such spatial targeting approaches need to be carefully considered. Indeed, regionally differentiated schemes may inadvertently disadvantage certain farm types or regions and thus be perceived as unfair, which may lower farmers' willingness to participate [73].

Enhancing parcel-level spatial targeting, potentially supported by digital farm management information systems [74], offers the opportunity to design more ambitious AES that not only cater to biodiversity objectives but also encompass a broader spectrum of ecosystem services [48]. Currently, targeted schemes often revolve around singular objectives, such as creating habitats for specific species (e.g., the corn bunting, *Emberiza calandra*, in the UK or the northern lapwing, *Vanellus vanellus*, in Czechia) or addressing individual environmental issues, such as soil erosion. The rationale behind spatial targeting is the belief that applying AES to the most suitable or vulnerable land parcels yields greater cost-efficiency in producing environmental benefits than horizontal (i.e., nontargeted) adoption strategies, which tend to include a large number of farms, make modest demands on farming practices, and pay correspondingly little for the environmental benefits provided [75]. On the other hand, spatial targeting may entail increased private and public transaction costs, for example, due to greater administrative efforts, and thus addressing multiple conservation or environmental goals (rather than a single objective) is more challenging. Digital farming technologies could facilitate compliance monitoring in AES, but they are currently not used for reporting [76].

However, the potential benefits may, in many cases, outweigh the additional efforts [75,77]: for example, BESTMAP's biophysical models [10] (Box 4) have demonstrated that targeting multiple objectives is feasible, as AES often yield positive impacts on biodiversity and the provision of multiple ecosystem services (e.g., nutrient retention and carbon sequestration) [78]. These synergistic effects are often contingent on scale and landscape context [79], such as the potential for a cumulative effect of small-scale measures over larger areas. Consequently, spatially targeted measures have the capacity to delineate zones that promote increased levels of biodiversity and ecosystem services [48], but achieving this outcome requires the application of spatial optimization techniques [80] and consideration of the cross-scale effects that different measures may have on distinct environmental objectives [81].

Co-designed, more flexible AES

More flexible approaches allow for adaptation to local conditions and encourage farmer engagement by aligning more closely with their professional practices, values [82], and ecological goals [83–85]. The involvement of farmers in defining and redesigning AES is crucial, as they have local knowledge and ultimately decide whether to adopt these measures [86]. We therefore advocate for the co-design of AES, defined as 'the conceptual development and participatory design of conservation measures for a specific region (typically at the landscape level) through close collaboration between farmers, scientists, and other stakeholders (e.g., other practitioners, conservation experts, agricultural advisors, and policymakers)' [87]. This collaborative approach is essential for increasing the uptake of AES and synchronizing agricultural actions at a larger spatial scale.

Co-design can address three primary obstacles to AES adoption: (i) ensuring that proposed measures are feasible within day-to-day farming operations, which we found to be a major barrier to adoption [19,20], (ii) valuing farmers' experiences and building trust to facilitate ongoing exchanges between farmers, scientists, and other stakeholders [87], and (iii) providing additional information about actual costs to help set incentives that are sufficient for farmers to place AES not only on their least productive land. The iterative nature of the co-design process [87] allows AES to be tested in the field, enabling the assessment and maximization of their ecological benefits.

Top-down policies, therefore, need to be compatible with and facilitate local co-design efforts. Compatibility requires more nuanced spatial targeting of policies, as discussed above. Facilitation involves addressing issues such as farmers' willingness to collaborate; our interviews suggest that farmers rarely prefer to work together on implementing AES to achieve environmental goals that might be difficult to accomplish individually [20]. This contrasts with the ecological benefit of landscape-scale restoration, which has led to calls for a more collective approach to biodiversity conservation in agricultural landscapes [88]. One approach is to actively aid collaboration among farmers, which is presently hindered, rather than facilitated, by the CAP [41]; with the exception of the Netherlands, which restructured its national AES program into a collective approach in 2016 [89], collective AES are not yet available [90] or widespread in most other countries [80,91]. A recent meta-analysis has suggested that the success of collaborative efforts for sustainable agriculture is driven by the characteristics of the actors involved and the structure and organization of the collaboration [92]. Policies can play a supportive role, as in the Dutch case of 'agricultural collectives', which encourage farmers to form certified conservation organizations [93], or the new national Landscape Recovery scheme in the UK, which provides funding for a group of land managers to plan interventions at a regional scale and secure long-term bespoke payment agreements with the government [94]. Given the reluctance of farmers to form cooperatives [95], especially in Eastern Europe [20] where decades of socialist collectivization have shaped contemporary attitudes toward collaborative farming, efforts should also be made to use collaborative approaches only where they are essential to achieve ecological objectives (i.e., where landscape-level coordination is required, for example, for above-ground biodiversity or water-related benefits). In such contexts, investing resources into strengthening social capital is paramount [94,96,97]. Also, less formalized coordination incentives, such as agglomeration bonuses, can play an important role if designed well [98–100].

Fixed contracts also hinder the flexibility and adaptability of AES. As conditions change, agri-environmental actions may not proceed as planned or new local knowledge may emerge, necessitating adjustments to objectives. To increase flexibility, options could include allowing farmers to suspend, or even opt out of, contractual conditions [101] or offering opportunities for renegotiation. In some recent cases where private companies have developed their own incentive schemes to transition farmers to more sustainable production methods, these contracts allow greater flexibility and shorter durations (one such example is the AgoraNatura initiative).[vi] In our analysis of one such scheme (the Landscape Enterprise Network) in the UK (see Box 5 for agent-based modeling of AES adoption scenarios), we found that the same AES had a fourfold higher adoption rate when it was offered to farmers by their supply chain (with significantly reduced reporting and highly flexible conditions) compared with the public scheme [102]. There is hope that, with proper design, the established mechanism in the 2023–2027 CAP of annual 'eco-schemes' or short-term UK Sustainable Farming Incentives will improve the flexibility of AES offered to farmers. However, it is important to avoid making AES participation excessively bureaucratic (see the following paragraph), and to ensure that conditions do not discourage farmers from maintaining participation in AES long enough to achieve ecological benefits.

Another frequently promoted strategy to improve the flexibility and context-specificity of AES is the use of results-based schemes [103,104], which compensate farmers based on their achieved environmental results rather than on prescribed management actions. However, new results-based schemes should go beyond current schemes that often lack additionality because farmers preferentially enroll plots that already meet the requirements for payment [20]. This is in line with a recent literature review, which highlights that while enhancing the alignment of measures with farmers' needs can increase adoption, excessive alignment may amplify the self-selection bias to which voluntary measures are generally prone, favoring farms that already meet baseline requirements [105].

Better AES advisory support for (small) farms

Advisory services can reduce the perceived bureaucratic burden on farms, equipping them with essential management skills, fostering environmental awareness, and improving their confidence and understanding of AES. These services are instrumental in helping farms, both small and large, select appropriate AES [20,106]. Additionally, advisory services can help optimize the spatial targeting of AES described above, for example, by advising farms on where AES would be most effective.

Currently, farm advisory systems exist in all countries of the EU but vary widely in terms of accessibility [58]. To enhance their effectiveness, the cost of AES-related advisory services should not be so high as to deter participation. They should also be easily accessible, providing both ecological guidance—such as understanding landscape-level effects of land-use management—and administrative support to navigate the AES application process. The CAP 2023–2027 explicitly requires Member States to develop and strengthen Agricultural Knowledge and Innovation Systems (AKIS) to improve knowledge exchange, innovation, and advisory services in agriculture. By fostering collaboration between farmers, advisors, researchers, and policymakers, AKIS can enhance the capacity of advisory services to address both ecological and administrative challenges, ensuring that knowledge and innovations are effectively shared and tailored to local contexts.

Advisory support is vital, especially for small farms, which are the least likely to participate in AES [25]. This reluctance can be attributed to several factors, in particular, the limited administrative capacity of small farms [19,20], the absence of suitable land parcels [107], and insufficient outreach by policymakers [108]. Research shows that the availability of advisory services, combined with reduced bureaucratic hurdles, significantly increases AES adoption [55]. Ideally, these services should be managed by trusted, independent local entities that act as intermediaries between subsidy providers and farmers, facilitating education and easing the application process [94,96]. Additionally, engaging and incentivizing landlords and other stakeholders can further encourage farmers to adopt AES by providing the necessary support for effective implementation.

Public money for public goods

Current payment levels for AES under the CAP 'should cover additional costs and income foregone only resulting from commitments going beyond the baseline of mandatory standards and requirements established in Union and national law'.[i] In practice, these rates are often set by Member States based on average values [109], even though this is not strictly necessary.[vii] Rationally, most farmers only participate if their costs are below the assumed average costs, and they tend to enroll (parts of their) land where costs are particularly low [19,20]. For farmers, remuneration is the most critical factor in deciding whether to adopt AES and which ones to choose [105]. Yet, the concept of compensation for income foregone is not a primary consideration, as farmers often aim for additional financial benefits. For example, some farmers reported that when their farms already cultivate forage grasses for their livestock, they use the respective AES as a 'welcome source of income' [20]. In addition, our spatial analysis of AES placement confirms that AES are preferentially located on poor-quality land [14,15].

Despite the financial incentives, farmers often express skepticism about measures that focus on delivering public goods (e.g., results-based schemes rewarding farmers for achieving specific environmental outcomes) due to the risks involved. These schemes require investments without guaranteed rewards and expose farmers to penalties arising from external factors beyond their control. As a result, many farmers perceive these schemes as offering low value and prefer short-term measures, which are not always the most ecologically efficient. Furthermore, farmers' accounts suggest that long-term social obligations, such as maintaining family traditions or ensuring the farm's viability for future generations, outweigh the short-term funding periods of AES [19]. Better aligning AES funding structures with farmers' long-term priorities, for instance, through longer contract durations and reduced financial risk, could therefore help bridge this gap and improve uptake across EU countries.

The rationale for 'costs incurred/income foregone' is often linked to the 'Green Box' under the World Trade Organization Agreement on Agriculture. The Green Box specifies permissible domestic support expenditures, particularly allowing direct payments to producers as long as these payments are not tied to production decisions. In other words, while farmers receive payments from the government, these payments must not influence the type or volume of agricultural production ('decoupled payments'). However, we argue that the WTO's logic, which aims to avoid distorting production systems, does not preclude payments for the public goods that AES provide to society. Most AES either involve trade-offs with productivity or are applicable to a wide range of crops, meaning they do not affect the type of production system. If the WTO agreement were modified to clarify this point (albeit currently this seems to be an unrealistic goal), Member States would have a stronger rationale to pay for training, risk management, and externalities (including ecosystem services) while maintaining the agreement's spirit. Such changes would allow for higher payment rates, which could significantly increase the uptake of AES across Europe. Moreover, even under current WTO rules, a certain share of higher payments is possible [109].[vii] However, simply increasing payment levels will not necessarily improve the spatial allocation of AES. To avoid merely increasing windfall gains for participating farms, higher payments must be combined with improved, more targeted designs, such as results-based or hybrid payments [110–112] or the already discussed incentives for spatial coordination.

Finally, the overall budget for AES requires careful consideration. Research suggests that current funding levels may be insufficient to prevent the shift toward large-scale farming or to effectively promote sustainable agricultural practices [113]. Our modeling has shown that a 'conservation-oriented scenario', in which AES adoption (and consequently the budget) is increased, can significantly benefit farmland bird species [16]. However, budget increases achieved by repurposing funds from other CAP components must be accompanied by clearly defined ecological goals and robust monitoring to ensure that additional spending translates into measurable environmental benefits. This concern is particularly relevant with the introduction of eco-schemes, where the reallocation of funds might not adequately support the intended environmental outcomes.[viii] In addition, we acknowledge that AES funds do not always benefit local farming communities directly, and future research should examine how benefits are distributed across different beneficiary types and their implications for local economic resilience. However, our analysis prioritizes whether AES deliver measurable ecological outcomes, which remains the primary public good regardless of beneficiary type.

Improving the monitoring of AES success

To develop an effective monitoring plan for AES success, we propose focusing on three key elements. First, it is crucial to establish a standardized framework for collecting spatio-temporally comprehensive AES monitoring data. This framework should provide clear guidelines on what data to collect, how to collect it, and how often to collect it. Consistent data collection ensures that the information is comparable across different regions and over time, enabling the assessment of the direction and magnitude of environmental change—an approach often referred to as 'surveillance monitoring' [114]. Making this data readily accessible for researchers and other interested parties can enhance transparency and facilitate broader analysis and understanding of AES impacts. Furthermore, consolidating monitoring efforts within a standardized framework can improve cost efficiency by reducing duplication across smaller, fragmented projects [115].

Second, effective monitoring of AES outcomes requires clear communication and discussion of results among all stakeholders, including farmers, scientists, policymakers, and conservation experts. Establishing channels for regular feedback and interaction can help identify challenges and opportunities in real time, allowing for more responsive and informed decision-making. This collaborative approach ensures that the monitoring process is not only top-down but also incorporates valuable insights from those directly involved in implementing AES.

Third, despite standardization, monitoring plans should remain flexible and capable of evolving based on the outcomes of previous monitoring efforts. Targeted monitoring (*sensu* Sparrow *et al*. [114]), using methods specifically designed to answer particular questions, such as on the ecological effects of AES in a specific location, is the most effective way to identify the causes of local ecosystem change. Insights gained from such monitoring can inform adaptive management approaches, allowing stakeholders to refine and adjust AES to better meet environmental objectives. Co-designing these monitoring plans with input from all relevant parties ensures that they are practical, context-specific, and aligned with the needs and capabilities of those involved. This iterative process supports continuous improvement and optimization of AES strategies and is complementary to the standardized monitoring strategy.

Traditional biodiversity monitoring is often labor- and cost-intensive and relies on experts. To address the needed spatio-temporal coverage for AES monitoring, novel and cost-efficient monitoring tools that can be operated autonomously or by farmers will need to be included—not fully replacing but complementing human observations. Technology can help simplify monitoring through tools such as mobile species identification apps,[ix] artificial intelligence [116], autonomous sound recorders [117], camera traps [118], and remote sensing [119]. These tools can enable farmers to participate in or support monitoring efforts, significantly reducing costs [120,121]. For instance, results-based AES can leverage these technologies to track the presence and number of target species on a parcel, thereby improving the spatio-temporal resolution of monitoring efforts and enabling financial rewards to be tied directly to actual conservation outcomes [122]. These time- and cost-efficient monitoring technologies open new avenues for the development of novel AES targeting environmental objectives that have been difficult to monitor thus far, including the monitoring of a more diverse set of species and taxa. However, it is important that AES conservation goals remain ecologically meaningful and not be driven primarily by the ease of measurement, avoiding the prioritization of species or taxa simply because they are easier to monitor rather than because they require conservation [76].

Concluding remarks

Building on the proposals above, we envision a new conceptual framework for EU agricultural policy (Figure 1). Instead of the current top-down and inflexible approach, which is updated every 7 years through a new CAP, we propose a more adaptive, agile, and multiscale strategy. At the smallest scale, that of a region or county, effective engagement and co-design with farmers would generate bottom-up AES. Involving individual farmers, in some capacity, in the design process provides them with greater agency and would also center farmers' relational values–and how they shape conservation and farming practice—in policy processes, as recently suggested [82]. However, a major barrier to the success of such a framework is the lack of clear, spatially explicit environmental and biodiversity goals for most regions. Moreover, regional implementation must account for the diverse historical, economic, and social contexts across Europe, from the legacy of socialist agriculture in eastern regions to varying farm-size distributions and institutional trust levels, ensuring that policies are both coherent in principle and adaptive in practice. Without these goals, it is difficult to align AES with the specific ecological needs of different landscapes, leading to inefficiencies and missed opportunities for targeted conservation.

To address this, we propose that the adaptive framework include a process for defining and updating spatially explicit goals at the regional level (Figure 1 blue cycle), informed by

Outstanding questions

How can spatial targeting of AES be optimized across scales (from individual fields to landscapes) to maximize ecological outcomes while maintaining fairness across different farm types and regions?

What governance structures and incentive mechanisms most effectively foster collective farmer action for landscape-scale conservation, particularly in regions with legacies of low institutional trust?

How can co-design processes be standardized and scaled up without losing the local flexibility and contextual sensitivity that make them effective?

To what extent can novel monitoring technologies (including AI-assisted identification, passive acoustic monitoring, and remote sensing) replace or complement traditional biodiversity surveys in AES evaluation, and how should results-based payment schemes be designed to incorporate them?

What payment models best balance ecological additionality, farmer participation, and economic fairness? How should payment rates account for risk, transaction costs, and contributions to public goods beyond income foregone?

How do the long-term ecological impacts of AES compare across different European farming systems, and what minimum contract durations and spatial extents are required to achieve measurable biodiversity recovery?

How can adaptive, multiscale AES policy frameworks be institutionalized within CAP governance cycles without compromising long-term ecological commitments or farmer planning security?

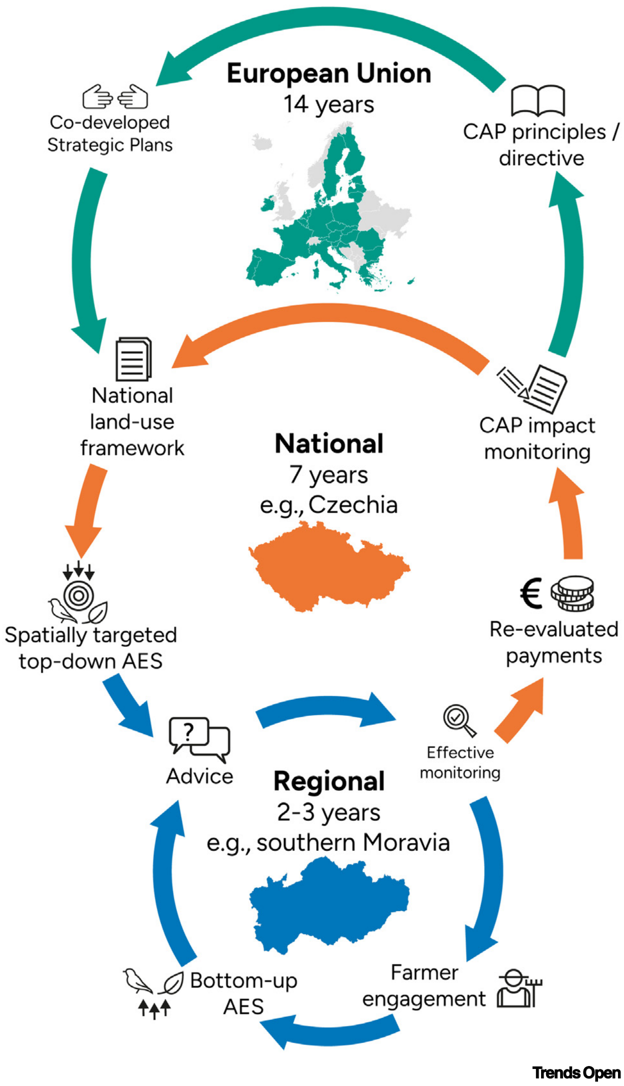

Figure 1. A new conceptual framework for EU agricultural policy. Our proposed framework integrates bottom-up and top-down approaches across three governance levels: European Union (14-year cycle), national (7-year cycle), and regional (2–3-year cycle). At the regional level, agri-environmental schemes (AES) are co-designed with farmers and guided by spatially explicit environmental and biodiversity goals, ensuring tailored and adaptive incentives. National-level policies focus on a comprehensive land-use framework and spatially targeted AES, while the EU level provides overarching principles and long-term planning through a CAP directive. Enhanced monitoring, advisory services, and iterative updates at all levels aim to align ecological and agricultural priorities, ensuring measurable environmental outcomes and fairer compensation for farmers. The figure was produced in Adobe Illustrator. CAP: Common Agricultural Policy.

robust ecological data and stakeholder input. These goals would guide the co-design process and ensure that AES are not only tailored to farmers' needs but also aligned with broader environmental objectives. Measures could evolve every 2–3 years, allowing for effective learning and adaptive policymaking while addressing farmers' concerns about frequent AES changes. This approach would be supported by enhanced advisory services that leverage modern technologies and provide 'on-the-ground' assistance tailored to individual farm contexts. Improved monitoring of AES implementation and impact, guided by the spatially explicit goals, would ensure that public funds are not 'wasted' on marginal lands incapable of delivering the intended public goods.

This rapid policy cycle would be embedded within a national 7-year cycle (Figure 1 orange cycle), similar to the current CAP. At the national level, the focus would shift to developing and updating a comprehensive land-use framework that integrates CAP strategic plans with other EU and national policies, ensuring a coherent vision for prioritizing public spending. Spatially targeted, top-down AES would complement those co-designed with farmers, creating a comprehensive and balanced set of incentives. For example, the top-down measures could address large-scale, cross-boundary

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1. Bartkowski, B. *et al*. (2023) Adoption and potential of agri-environmental schemes in Europe: cross-regional evidence from interviews with farmers. People and Nat. 5, 1610–1621. 10.1002/pan3.10526

Drawing on 124 farmer interviews across five European regions, this study provides the primary empirical evidence that underpins our identification of systemic barriers (including inflexibility, bureaucratic burden, and misaligned incentives) as the central obstacles to the success of agri-environmental schemes.

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This perspective argues that incremental improvements to AES are insufficient and that structural transformation is required—directly supporting our call for a new adaptive, multiscale policy framework rather than further piecemeal reform.

3. Roilo, S *et al.* (2023). Landscape-level heterogeneity of agri-environment measures improves habitat suitability for farmland birds. Ecol. Appl. 33, e2720. 10.1002/eap.2720

This study provides direct empirical evidence that the spatial configuration and diversity of AES measures, not merely their extent, determine ecological outcomes, underpinning our central argument for spatially explicit, landscape-scale AES design.

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This analysis quantifies the scale of inefficient AES spending across the EU, providing a compelling economic argument for a fundamental policy redesign that our manuscript advocates, particularly regarding spatial targeting and evidence-based allocation.

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environmental goals that require high spatial coordination (e.g., regional water quality standards), while bottom-up, co-designed measures would use local farmer knowledge to implement practices that are specific to the local context (e.g., enhancing local pollinator habitats). Consistency and complementarity would be ensured by using a top-down framework to set the 'spatial boundary conditions' (e.g., using archetypes to identify priority zones), where farmers have the flexibility to co-design specific actions. In addition, enhanced monitoring of AES impacts would enable evidence-based policymaking, allowing payment rates to reflect not only the 'income foregone/cost incurred' model but also the broader value of farmers' risks, investments, and contributions to public goods. This approach would facilitate clearer and more scientifically robust reporting of CAP impacts, focusing on measurable environmental and biodiversity gains rather than simply tracking expenditures. At the European scale (Figure 1 green cycle), policy could adopt a longer timescale, perhaps changing the CAP agreement to run on a 14-year cycle to allow for more ambitious, long-term planning. Overarching goals and principles would be established through a new CAP Directive, with strategic plans co-developed by Member States and the European Commission to set clear targets for result and impact indicators.

Since the mandatory implementation of AES in 1992, much of the criticism regarding their effectiveness has remained unchanged. We argue that a fundamental overhaul of AES design across all political levels is essential to transition European agriculture toward a sustainable future. This overhaul must address persistent and well-known challenges, such as the lack of spatially explicit goals, insufficient alignment between ecological and agricultural priorities, and the need for more adaptive, evidence-based policymaking (see Outstanding questions). Only by tackling these systemic issues systematically and across spatial and administrative scales can AES fulfil their potential to deliver meaningful environmental outcomes while also providing significant benefits to farmers, such as fairer compensation for their efforts, reduced financial risks, and greater recognition of their role as stewards of the environment.

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By showing that farming system archetypes predict AES uptake across contrasting European regions, this study provides the cross-regional empirical foundation for our proposal to use archetype-based spatial targeting and tailored co-design in a reformed policy framework.

Author contributions

All authors jointly developed the conceptualization of this opinion article, researched the literature, and wrote the original draft. All authors reviewed and edited the final version of the manuscript.

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Declaration of interests

The authors declare no competing interests.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used Claude AI in order to check grammar, spelling, and references. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Resources

[i]https://eur-lex.europa.eu/eli/reg/2021/2115/oj/eng

[ii]https://riojournal.com/topical_collection/148/

[iii]https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cmef/sustainability/impact-cap-habitats-landscapes-biodiversity_en

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