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# River restoration *via* CAP eco-schemes: current support and future opportunities for blue infrastructure

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Freshwater ecosystems across Europe face significant degradation, with agricultural practices playing a central role. The 2023–2027 Common Agricultural Policy (CAP) introduces new eco-schemes that could support river restoration, a key goal of EU environmental legislation. This study presents a systematic analysis of eco-schemes in all 27 EU CAP Strategic Plans, assessing their alignment with river restoration goals. We reviewed over 130 approved eco-schemes, classifying them according to their potential to support eleven predefined restoration actions (e.g., floodplain reconnection, instream habitat improvement). Support was categorized as direct, indirect, potential, or not supported. The analysis combined AI-assisted text processing with manual validation. Results reveal considerable variation in how Member States use eco-schemes to support river restoration. While some countries offer multiple schemes with direct or indirect relevance, most focus on maintaining existing practices. Only a limited number explicitly support actions like riparian buffer restoration or wetland creation. Over 30% of all eco-schemes fall into the "potential" category, where design could be enhanced to support freshwater restoration more explicitly. Although river restoration is not a core target of CAP eco-schemes, this new instrument creates strategic opportunities to address freshwater degradation. The current implementation, however, reflects limited ambition and uneven alignment with EU water policy goals. The paper proposes adjustments to scheme design and classification methods to better embed blue infrastructure restoration within the CAP framework. This study offers the first EU-wide analysis of eco-schemes for river restoration, providing a critical baseline for future policy development and mid-term CAP revisions.

KEYWORDS

**agricultural policy, eco-schemes, environmental governance, rural develoment, water management**

## 1 Introduction

The ecological restoration of fluvial and palustrine systems is critical for recovering aquatic biodiversity, improving water quality and biogeochemical cycling, and enhancing ecosystem resilience in the face of climate change (Wohl et al., 2015). A key objective is to re-establish longitudinal connectivity and to restore the geomorphic and ecological structure of river channels and their riparian zones. Equally important is the revitalization of lateral connectivity, through the diversification of floodplain habitats and the reactivation of wetland mosaics that are hydrologically connected to the river system (Keesstra et al., 2018). This includes the reestablishment of natural flow regimes and the removal of barriers to species movement (Baeza et al., 2024). In agricultural floodplains, remaining blue infrastructures—such as meanders, oxbows, ponds, and side channels—are often scarce, degraded, and insufficiently managed. These features are vital remnants of natural ecosystems, supporting biodiversity and sustaining essential ecological functions. River restoration in these settings can generate substantial ecosystem service benefits, including sediment and erosion regulation, mitigation of flood extremes, filtration of nutrients and pollutants, and the provision of clean water and cultural values (Basak et al., 2021; Bernhardt and Palmer, 2011; Roni et al., 2015). Restoration also contributes to maintain viable animal metapopulations within irrigated landscapes, support functions such as pollination and natural pest control.

Freshwater systems are among the most anthropogenically impacted ecosystems worldwide (Sala et al., 2000), with European rivers and wetlands experiencing extensive degradation (Uehlinger et al., 2009; Venter et al., 2016). Consequently, riverine restoration and integrative management strategies have become central to achieve good ecological status under EU directives (Flávio et al., 2017; Tolvanen and Aronson, 2016; Zacharias et al., 2020). The Water Framework Directive (WFD) (European Parliament and Council of the European Union, 2000) (Directive 2000/60/EC) in effect across all Member States since 2009, serves as the cornerstone of EU water policy, mandating good ecological and chemical status for all surface waters. Realizing these goals requires alignment with sectoral policies that influence water systems—particularly agriculture, which plays a major role in both the degradation and restoration of freshwater ecosystems. The Nature Restoration Regulation (NRR) (Regulation (EU) 2024/1991) reinforces these ecological ambitions by setting a binding objective to restore 25,000 km of free-flowing rivers by 2030, primarily *via* removal or retrofit of obsolete barriers (European Parliament and Council of the European Union, 2024). Because such structural works typically exceed what annual, farm-level eco-schemes can deliver, our analysis focuses on eco-schemes' complementary contribution (e.g., reducing diffuse pressures, protecting riparian condition) within the wider policy mix. Beyond the NRR, eco-schemes operate alongside the EU's LULUCF (Land Use, Land-Use Change, and Forestry) Regulation, which sets binding net-removal targets toward 2030; aligning agricultural measures (e.g., riparian woody cover, wetland rewetting) with both NRR connectivity benchmarks and LULUCF accounting underscores that eco-schemes are one lever within a wider policy mix (European Parliament and Council of the European Union, 2018; 2023).

Beyond setting headline targets, the Nature Restoration Regulation (NRR) creates operational hooks that matter for agriculture–water coherence. Article 9 requires Member States to compile an inventory of artificial barriers to surface-water connectivity, identify which should be removed to meet Article 4 restoration targets, and prioritise removal of obsolete barriers—anchoring this free-flowing rivers objective in concrete national planning. In parallel, National Restoration Plans must explicitly explain their interplay with each country's CAP Strategic Plan, creating a formal bridge between restoration targets and agricultural spending. These provisions make eco-scheme design and monitoring directly relevant to NRR delivery (Manzoni et al., 2025). Recent EU-wide benchmarking using a semantic interval scale finds that while CAP Strategic Plans appear "greener", alignment with NRR objectives remains uneven and often lacks measurable criteria, underscoring the need to coordinate CAP with NECP and LULUCF delivery to avoid overlaps and conflicting goals (Perissi, 2025).

The Common Agricultural Policy (CAP) is one of the world's most comprehensive and financially significant agricultural policy framework, accounting for approximately 31% of the EU's total annual budget in the 2023–2027 programming period (European Commission: Directorate-General for Communication, 2023). Since its origin in 1957, the CAP has evolved through successive reforms and now operates under a two-pillar structure: Pillar I provides area-based direct income support to farmers—consuming over 70% of the CAP budget—while Pillar II supports rural development, including agri-environment-climate measures (AECMs), investments in sustainable land use, and other voluntary environmental tools. Within this policy architecture, the CAP plays a pivotal role in the management of freshwater ecosystems. Agriculture is both a major driver of degradation and a potential contributor to restoration—provided that appropriate incentives are in place (European Commission, 2017).

Historically, however, the CAP has lacked a strong environmental orientation. A growing body of policy research now calls for deeper transformation, including a redirection of agricultural subsidies toward the provision of public goods such as biodiversity, clean water, and river restoration (Midler et al., 2023). The current CAP cycle (2023–2027) represents a partial shift in this direction. It introduces enhanced environmental conditionalities and expands instruments—such as eco-schemes—that are more closely aligned with the ecological objectives of the Water Framework Directive (WFD) and broader EU sustainability goals (European Environment Agency, 2021).

Eco-schemes, newly reinforced in the 2023 reform, are a key component of Pillar I. They provide annual, voluntary payments for farmers who adopt environmentally beneficial practices, aiming to align agricultural production with broader ecological goals–such as water and soil protection, biodiversity conservation, and climate mitigation. However, the extent to which this recognition translates into practical support for riverine restoration—and how consistently this is applied across Member States—remains unclear. Unlike agri-environment-climate measures (AECMs) or non-productive investments under Pillar II—which are typically multiannual, localized, and shaped by subsidiarity—eco-schemes are nationally defined but require EU-level approval. This structure creates a harmonized implementation mechanism across Member States, supported by mandatory funding allocations. Their standardized format makes them particularly suitable for systematic, cross-country comparison of environmental ambition and implementation. To facilitate such comparisons, the European Commission's Joint Research Centre has developed classification systems based on farming practices, supporting EU-scale evaluation of eco-schemes' climate and environmental contributions (Angileri et al., 2024). Early cross-country evidence shows wide heterogeneity in eco-scheme design: across 15 Member States the number of measures ranged from 3 to 21, with some countries adopting points systems (e.g., Netherlands; France for crop diversification) while others bundled multiple requirements into single measures. Many options were derived from former greening or Pillar II AE(C)S, with strong emphasis on biodiversity features and non-productive land, plus water-protection practices such as buffer strips, reduced fertiliser use and precision application. This diversity underscores both the flexibility and the complexity inherent in national implementations (Runge et al., 2022).

Some Member States are testing results-based points designs. In the Netherlands, the eco-scheme offers a menu of 22 activities scored across five objectives (climate, soil/air, water, landscape, biodiversity), with bronze/silver/gold payment tiers per hectare; this illustrates both higher ambition and design complexity inherent to results-oriented implementations (Jongeneel and Gonzalez-Martinez, 2023). Recent evidence from a labelled discrete-choice experiment with 360 farmers in Flanders shows a broad aversion to voluntary agri-environmental contracts, but a consistent preference for 1-year, more flexible eco-schemes over multi-annual AECM—especially where AECM compensation is result-dependent. Farmers were particularly sensitive to full bans on fertilizers and herbicides, and valued procedural flexibility in result-based contracts (e.g., inspection modalities), underscoring how contract design can tilt uptake toward lighter-touch options (Anougmar et al., 2025). A large, cross-Member-State expert synthesis cautions that eco-schemes will only deliver biodiversity gains if they prioritize evidence-based actions, ring-fence sufficient budgets for biodiversity options, and ensure coherence with conditionality and AECMs; otherwise, ambition risks being watered down by funding low-impact or pre-existing practices. The same assessment recommends multi-annual or progressive points/bonus designs and collective delivery where outcomes depend on landscape connectivity. (Pe'er et al., 2022).

The legal foundation for eco-schemes is set out in Article 31 of Regulation (EU) 2021/2115, which obliges Member States to implement schemes that promote agricultural practices beneficial to the climate, environment, and animal welfare. These measures must go beyond baseline legal requirements [Art. 31(5)] and can be delivered as incentives or compensation for income foregone [Art. 31(7)]. Importantly, eco-schemes must address at least two environmental priorities—such as biodiversity, water quality, and soil health—all of which are directly relevant to the restoration of blue infrastructure and the enhancement of freshwater ecosystems in agricultural landscapes.

This study assesses the extent to which current CAP eco-schemes implemented across EU Member States explicitly support river restoration or enhance the ecological functioning of fluvial systems. Specifically, we examine the degree to which these schemes incentivize actions that improve riverine environments, sustain key ecological processes, and support the delivery of freshwater-related ecosystem services. We hypothesize that, while a broad range of eco-scheme measures exists, implementation remains highly heterogeneous across countries and lacks alignment with a unified ecological vision for river restoration. Our analysis explores the potential for a more harmonized and ecologically grounded approach to emerge—one that embeds blue infrastructure objectives more explicitly within CAP design and is guided by standardized indicators reflecting minimum ecological thresholds and functional integrity.

# 2 Methodology

## 2.1 Scope and rationale

The methodological approach was designed to trace, classify, and compare eco-scheme measures relevant to river restoration across all 28 EU CAP Strategic Plans. As illustrated in Figure 1, the workflow consists of a sequence of procedural steps (shown as blue rectangles), including the identification of eco-scheme sections, manual categorization, and validation. These are complemented by AI-assisted analysis (green squares), where a large language model (ChatGPT) was used to extract relevant content from each Strategic Plan. Key outputs (yellow parallelograms) were generated throughout the process, such as the classification of support categories, country-level summaries, and the final comparative dataset used to produce Figures 2–4 and Supplementary Table S1.

The analysis began with the identification of eco-scheme sections in each national Strategic Plan, alongside the definition of eleven predefined river restoration measures. Using ChatGPT, each eco-scheme section was screened through a standardized prompt to extract relevant information, including direct quotes, page numbers, translations, and ecological descriptions. All outputs were manually reviewed and validated for accuracy and ecological relevance. While our classification is CAP-oriented, we interpret freshwater-relevant measures in light of NRR Article 9 on river connectivity so that findings can inform National Restoration Plan design and monitoring (Manzoni et al., 2025).

Each eco-scheme was then categorized into one of four predefined support categories: direct, indirect, potential, or not supported. These classifications were compiled into a structured workspace (Notebook LM), generating a list of countries and eco-schemes supporting each restoration action. The results were recorded in a master table (Supplementary Table S1) and visualized in Figures 2–4. As an alternative to our transparent four-category classification, recent EU assessments have applied semantic interval scaling to convert qualitative plan evaluations into comparable scores for NRR benchmarking; we note this approach as complementary to our objective here (Perissi, 2025).

This study does not quantify whether eco-schemes are sufficient to meet binding restoration or climate targets under the NRR or LULUCF; rather, it provides a qualitative, EU-wide classification of policy intent that can be coupled to quantitative baselines and uptake scenarios in future work.

## 2.2 Data collection

In October 2024, we retrieved the most recent official versions of each country's CAP Strategic Plan directly from the websites of the relevant national ministries or managing authorities. Only documents published in national languages were used to ensure alignment with the authoritative, binding versions of each plan. No official translations or summaries were consulted at this stage. The study covered the following Member States: Austria, Belgium

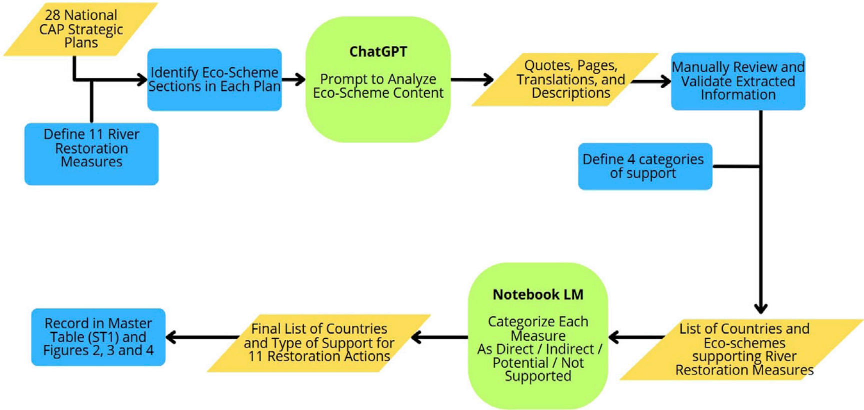


FIGURE 1
Workflow for the analysis of the EU CAP national strategic plans. Blue rectangles represent procedural steps undertaken by the research team (e.g., data retrieval, classification, validation). Yellow parallelograms indicate intermediate or final outputs generated throughout the workflow (e.g., lists, classifications, and result compilations). Green squares represent AI-supported analytical steps where a large language model (ChatGPT) was used to assist document analysis.

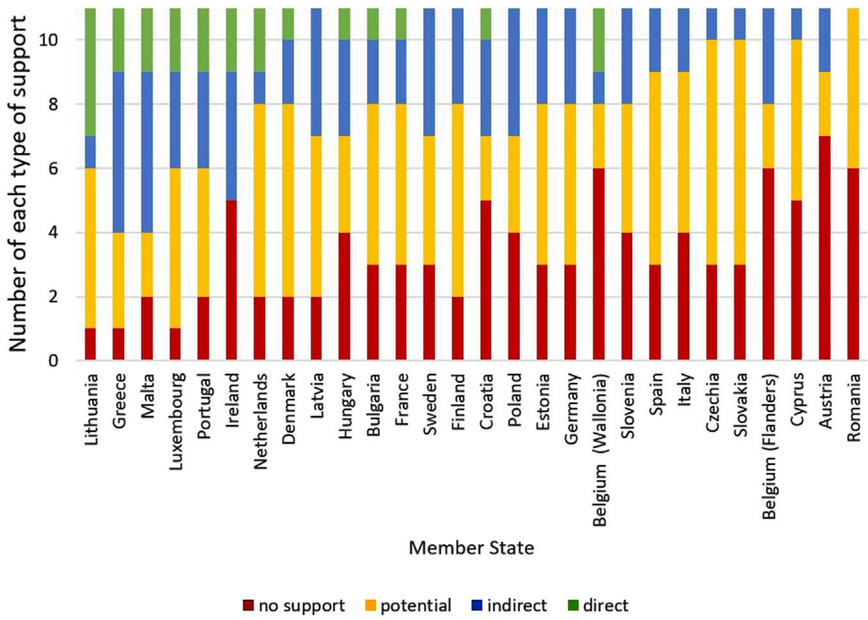


FIGURE 2
Distribution of support categories by Member State across the 27 national EU CAP Strategic Plans. Each bar shows the number of eco-scheme measures per country assigned to four categories—direct, indirect, potential, and no support—based on eleven predefined river-restoration actions (e.g., floodplain reconnection, instream habitat improvement, riparian vegetation management). Countries are ordered by an ordinal composite score (direct = 1, indirect = 2, potential = 3, no support = 4) solely for visual readability; interpretation should rely on each country's category composition rather than the order itself. The y-axis ranges from 0 to 11 measures. Note: Belgium appears twice (Flanders; Wallonia) because it has two approved CAP Strategic Plans; totals therefore reflect 28 plans for 27 Member States.

(Wallonia and Flanders analyzed separately), Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden. Belgium is the only EU Member State with two CAP Strategic Plans—one for Flanders and one for Wallonia—approved by the European Commission on 5 December 2022. Accordingly, our corpus comprises 28 plans across 27 Member States; the two Belgian plans are analysed separately. (European Commission: Directorate-General for Communication, 2023; European Commission, 2022).

Our document corpus consisted of the authoritative national CAP Strategic Plans. We did not systematically review implementing regulations (e.g., ministerial decrees, paying-agency

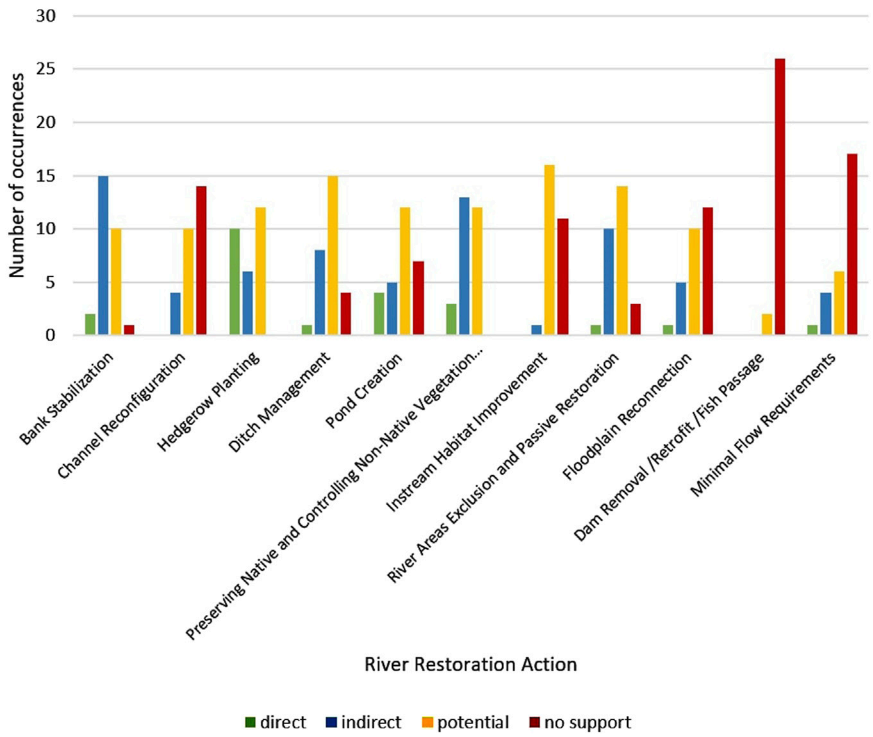


FIGURE 3
Support Classification Frequency per River Restoration Measure across the national 27 EU CAP Strategic Plans.

guidance), annual budget allocations, or realised uptake statistics. Consequently, the classifications reported here reflect plan-level design intent rather than observed implementation; this is revisited in the Discussion (ECA, 2024; Midler et al., 2023).

## 2.3 Eco-scheme extraction and AI-assisted screening

We identified the relevant sections within each Strategic Plan by consulting the table of contents in the original language versions. Owing to the standardized structure of the CAP Strategic Plans, the eco-scheme content was typically located in chapters labeled with intervention code 31 (referring to Article 31 of Regulation EU 2021/2115) or under headings closely corresponding to "eco-schemes." Once located, these sections were extracted and submitted to ChatGPT (GPT-4), a large language model developed by OpenAI, for content screening and interpretation.

We primed the model with detailed written instructions and definitions of eleven freshwater restoration measures, drawn from scientific literature and policy frameworks. These included: *Bank stabilization; Channel reconfiguration; Hedgerow planting; Ditch management; Pond creation; Management of native and non-native riparian vegetation; Instream habitat improvement; River area exclusion and passive restoration; Floodplain reconnection; Dam removal or retrofit and fish passage; Minimum flow requirements*. *Hedgerow planting*, though sometimes considered a terrestrial measure, was included for its contribution to riparian buffer integrity, erosion control, and nutrient interception—particularly in cropland contexts. This rationale and the full set of measures were previously defined in Santos et al. (2025). These measures were selected for their relevance in restoring the ecological integrity and hydrological function of degraded freshwater systems.

## 2.4 Document analysis and validation

For each Strategic Plan, ChatGPT was instructed to:

- Read the eco-scheme section;
- Identify any funding mechanisms or policy measures that could support river restoration;
- Return direct quotations (with page numbers and original language), provide translations, and briefly explain each measure's ecological relevance.

The model was prompted to be exhaustive, avoid speculation, and limit its output to measures that could be clearly linked to the predefined restoration categories. All outputs were verified against the original documents by the research team—checking both linguistic accuracy and ecological context—to ensure classification reliability and source traceability.

To ensure reliability, all AI-extracted items were verified by the lead author against the authoritative national-language version of each Strategic Plan. Verification involved (i) checking that each quotation and page reference existed in the source document, (ii) confirming meaning in context, and (iii) mapping the item to one of

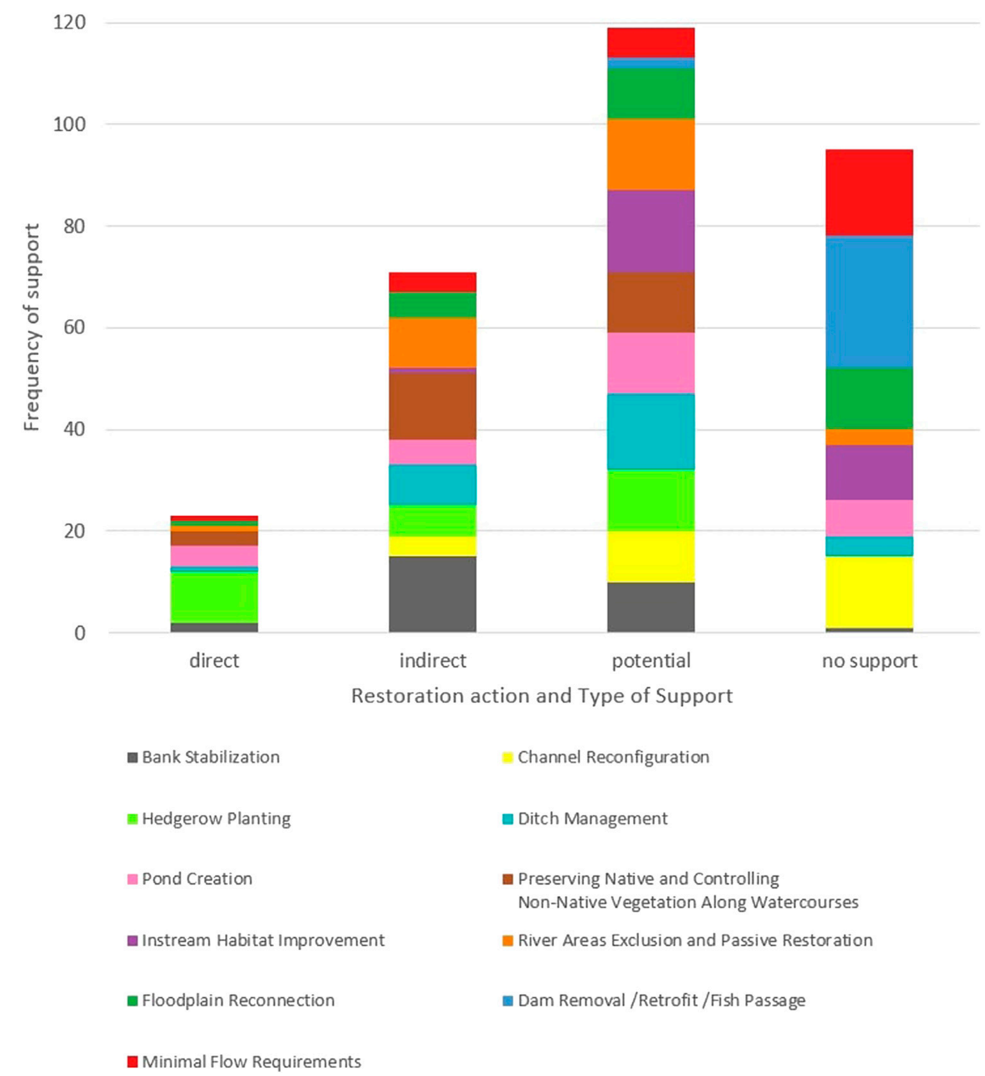


FIGURE 4
Overall Frequency of Support Types Across All River Restoration Measures.

the eleven predefined restoration actions using a decision rubric applied consistently across countries. Where eligibility criteria or spatial targeting were ambiguous, we adopted a conservative coding rule and assigned the measure to "potentially supported" or "not supported." For transparency and replication, Supplementary Table S1 reports, for every classification, the exact text excerpt (with page number) and a brief justification. We did not compute a misclassification rate nor conduct multi-coder reliability in this version; this is noted as a limitation below.

## 2.5 Categorization and synthesis

All extracted data were imported into Notebook LM, a structured workspace developed by Google (2024) and powered by generative AI, used to organize and review the findings. Each eco-scheme measure was classified into one of four categories, based on its relevance to river restoration:

- Directly supported: Explicit references to river restoration or aquatic habitat rehabilitation as a stated objective.

Example: In Ireland, pond creation is directly supported through the eco-scheme measure "Action 1 – Space for Nature". Ponds are considered non-productive landscape features that contribute to biodiversity and aquatic habitat enhancement, and their inclusion is explicitly encouraged. The measure provides financial support ranging from €60 to €77 per hectare, depending on complexity.

- Indirectly supported: Restoration is a likely secondary outcome, though not explicitly mentioned.

Example: The Dutch eco-scheme focusing on sustainable land and water management encourages practices like buffer strips and reduced chemical inputs, which, while not directly mentioning river restoration, benefit aquatic ecosystems.

- Potentially supported: Restoration is not stated but could plausibly be supported based on eligibility criteria.

*Example*: In Italy, ditch management is potentially supported through the eco-scheme measure "*ECO-4 – Extensive Forage Systems with Crop Rotation*", which promotes reduced inputs and erosion control. These practices may improve the ecological condition of agricultural ditches, thereby supporting water quality and hydrological function.

- Not supported: None of the eleven restoration measures were referenced in any form.

Example: A country's eco-scheme focusing solely on crop diversification without any mention of water management or habitat restoration would fall into this category.

The results were compiled into a structured matrix (Supplementary Table S1), with countries as rows and restoration measures as columns. For each cell, we recorded the level of support (directly, indirectly, potentially, or not supported), the specific eco-scheme code assigned by the Member State, a justification for the classification, and—where applicable—funding levels expressed in euros per hectare.

To summarize across categories for visualization, we constructed an ordinal composite score that applies a simple monotonic penalty scheme to support types (direct = 1, indirect = 2, potential = 3, no support = 4). The mapping reflects a conceptual "distance-to-intent" scale: measures that explicitly target river restoration receive the lowest penalty; measures whose contribution is contingent or absent receive higher penalties. We selected a simple linear mapping for transparency and ease of communication, consistent with guidance for composite indicators when theory does not prescribe parametric weights; importantly, the score is used only to order countries in Figure 2 and is not interpreted as an effectiveness metric.

The resulting composite index provides an illustrative ordering of countries for Figure 2. Country positions should be read qualitatively; the category distributions in Figures 2–4 and the verbatim evidence in Supplementary Table S1 constitute the primary basis for comparison. We did not compute inter-coder reliability for this version and acknowledge this as a limitation. To support independent verification, Supplementary Table S1 reports, for each classification, the source excerpt (original language with page reference) and a brief justification.

This classification reflects a 2024 plan snapshot; any references to future pathways are qualitative and intended to illustrate how category composition could evolve with policy adjustments and uptake.

## 3 Results

Eco-scheme support for river restoration varies widely across EU Member States. The findings below summarise plan-level provisions extracted from Strategic Plans; they do not capture realised uptake or adjustments made through national implementing acts during delivery (ECA, 2024). As shown in Figure 2, Lithuania provides the strongest direct support, with four distinct eco-scheme measures explicitly targeting river restoration objectives. In contrast, 15 of the 28 plans (27 Member States) offer no direct support for any of the eleven restoration actions considered. At EU scale there is no simple geographic gradient explaining support levels; differences are not accounted for by country size, latitude or broad agricultural profile.

Figure 3 shows how often each of the eleven restoration actions falls into the four support categories across all plans. Dam removal/retrofit and fish passage and minimum-flow requirements most frequently fall under "no support" (26 and 17 occurrences, respectively). By contrast, hedgerow planting is most frequently classified as receiving direct support (10 occurrences). Bank stabilisation and preserving native/controlling non-native riparian vegetation most often appear as indirect support (15 and 13 occurrences, respectively). Figure 4 presents the overall frequency of support types across all river restoration actions. Most records fall under the "potential" support category (117), indicating many eco-schemes could plausibly contribute to river restoration, but lack explicit targeting. The "no support" category follows (92 occurrences), highlighting a substantial gap in the direct inclusion of river restoration actions within CAP eco-schemes. The "indirect" category accounts for 68 occurrences, while the "direct" support category registers the lowest frequency (23 occurrences), confirming that few Member States explicitly designed eco-schemes with river restoration as a primary objective. These findings align with the detailed analysis presented in Figure 3, reinforcing the limited ambition of current eco-schemes in promoting freshwater ecosystem restoration. Measures most relevant to free-flowing rivers—barrier removal/retrofit and fish passage, and floodplain reconnection—are not directly supported in our classification and, where any link exists, appear only as indirect or potential support. By contrast, passive, farm-scale practices (e.g., riparian exclusion, hedgerows, soil cover) dominate portfolios. These results indicate that eco-schemes will play a complementary role for the NRR target, while connectivity gains at scale depend on multi-annual, collective instruments and basin planning (Darre et al., 2025; Manzoni et al., 2025).

Table 1 provides a summarized overview of the eco-schemes identified as applicable to river restoration across the 27 EU Member States analysed. For each country, the total number of eco-schemes and the subset supporting river restoration—whether directly, indirectly, or potentially—are presented. A brief description of each applicable measure is included to facilitate interpretation. This table complements the previous figures by offering a synthetic yet detailed reference of the most relevant eco-schemes, while the complete classifications is available in Supplementary Table S1.

Regarding regional patterns and indicative policy typologies, across Member States, the composition of support categories suggests consistent regional patterns. Many Mediterranean countries prioritise passive, on-farm measures linked to grazing and erosion control (e.g., riparian exclusion, vegetative cover), with direct support for hydromorphological works largely absent. Several Western and Northern countries emphasise indirect support *via* soil management, nutrient reduction, or biodiversity scoring systems—actions that can benefit freshwater ecosystems but do not explicitly target river restoration. Parts of Central and Eastern Europe include a somewhat broader set of freshwater-

**TABLE 1** Summary of eco-schemes with potential relevance for river restoration in the 2023–2027 CAP Strategic Plans across EU Member States.

| Member state | Total number of eco-schemes/ applicable for river restoration | Eco-schemes for river restoration |
|---|---|---|
| Austria | 4/2 | • 31-01: Catch crop cultivation; reduces soil erosion and nutrient runoff — may support bank stabilization and ditch management.<br>• 31-03: Erosion control in vineyards/orchards; year-round vegetation stabilizes banks — may support bank stabilization and hedgerow planting. |
| Belgium (Wallonia) | 6/2 | • 143: Biodiversity and ecosystem services; may support bank stabilization *via* woody and aquatic elements. Directly supports hedgerow planting.<br>• 141: Soil erosion prevention; may support bank stabilization by reducing erosion. |
| Belgium (Flanders) | 13/4 | • Eco-schemes on buffer strips (1.10), erosion control techniques (1.12), and ecologically managed grassland (1.6) may support bank stabilization, ditch and river plant management, and passive restoration through erosion control, runoff reduction, and riparian protection.<br>• Cultivation of biodiversity-friendly crops (1.8) may support hedgerow planting. |
| Bulgaria | 8/4 | • Eco-schemes I.B.2, I.B.5, I.B.6, and I.B.7 support biodiversity, ecological infrastructure, and sustainable land management across crops, pastures, and forests. Measures include hedgerow planting (I.B.2, €229.06–€286.33/ha), protective strips, controlled grazing, and landscape connectivity. Together, they may support bank stabilization, ditch management, floodplain reconnection, river plant management, and passive restoration. |
| Croatia | 7/7 | • Eco-schemes 31.03 and 31.05 focus on biodiversity and directly support hedgerow planting (31.03: €56.35–€68.87/ha), while also contributing to bank stabilization, river plant management, and instream habitat improvement.<br>• Schemes promoting soil conservation, organic fertilization, and nitrogen-fixing crops (31.06, 31.04, 31.01) may indirectly support instream habitat improvement, ditch management, and bank stabilization by reducing erosion and nutrient runoff.<br>• Low-impact grazing and preservation of natural grasslands (31.07, 31.02) may support river area exclusion, passive restoration, and riparian vegetation protection. |
| Cyprus | 2/2 | • Eco-schemes Α.Π. 3.1 and Α.Π. 3.2 focus on soil and nutrient management and reducing chemical impacts on water. Together, they may support hedgerow planting, ditch management, bank stabilization, river plant management, instream habitat improvement, and passive restoration by reducing runoff, improving soil quality, and protecting riparian areas. |
| Czechia | 2/2 | • Eco-schemes 05.31 (Whole Farm Eco-payment) and 06.31 (Precision Agriculture) promote environmentally friendly farming practices and optimized input use. Together, they may support bank stabilization, hedgerow planting, ditch management, river plant management, instream habitat improvement, floodplain reconnection, river area exclusion, passive restoration, and minimal flow requirements through erosion control, vegetative cover, runoff reduction, and sensitive area protection. |
| Denmark | 6/2 | • Eco-scheme 6: Sustainable grassland management; may support channel reconfiguration, ditch management, pond creation, river area exclusion, passive restoration, and floodplain reconnection through extensive grazing and runoff reduction.<br>• Eco-scheme 9: Biodiversity enhancement; directly supports river plant management and may support hedgerow planting and instream habitat improvement through small biotope creation and native vegetation preservation (€331–€496.52/ha; avg. €367.79/ha). |
| Estonia | 5/4 | • ÖK1: Environmentally friendly farming; may support hedgerow planting, ditch management, and instream habitat improvement through sustainable practices and reduced pesticide use.<br>• ÖK3: Ecological focus areas; may support hedgerow planting, pond creation, native vegetation management, and passive restoration in sensitive areas. |

(Continued on following page)

TABLE 1 (*Continued*) Summary of eco-schemes with potential relevance for river restoration in the 2023–2027 CAP Strategic Plans across EU Member States.

| Member state | Total number of eco-schemes/ applicable for river restoration | Eco-schemes for river restoration |
|---|---|---|
| | | • ÖK4: Preservation of ecosystem services on arable land; may support bank stabilization, channel reconfiguration, ditch and pond maintenance, and reduced agricultural pressure on riparian zones.<br>• ÖK5: Bee pasture support; may indirectly support riparian vegetation management through pollinator habitat promotion. |
| Finland | 4/4 | • 01: Winter cover crops; may support bank stabilization and reduce ditch runoff during winter.<br>• 02: Nature grasslands; may support channel reconfiguration, passive restoration, exclusion zones, and hydrological restoration by preserving natural pastures and native vegetation.<br>• 03: Green fertilizer grasslands; may support bank stabilization, ditch management, and improved water quality through erosion control and water flow management.<br>• 04: Biodiversity crops; may support hedgerow planting, pond creation, native vegetation management, and floodplain revegetation for habitat enhancement. |
| France | 1*/4<br>*divided into 6 pathways | • Preservation of Biodiversity; directly supports hedgerow planting (€45.46–€62.05/ha, ~€92.05/ha for organic, plus €7/ha bonus for ≥6% hedgerow cover) and may support bank stabilization, channel reconfiguration, ditch management, river plant management, and instream habitat improvement *via* agro-ecological infrastructure.<br>• Sustainable Soil and Water Management; may support bank stabilization, channel reconfiguration, and ditch management through reduced tillage and soil cover.<br>• Agroforestry; may support bank stabilization through tree and shrub planting near watercourses.<br>• Landscape Elements/ Buffer Strips/ Grassland Preservation; may support pond creation, river area exclusion, and passive restoration by maintaining undisturbed grasslands and excluding livestock near rivers. |
| Germany | 7/4 | • DZ-0401: Biodiversity and habitat preservation; may support bank stabilization, hedgerow planting, channel reconfiguration, pond creation, instream habitat improvement, and floodplain restoration through biodiversity and habitat connectivity measures.<br>• DZ-0403: Agroforestry management; may support instream habitat improvement and water quality enhancement.<br>• DZ-0404: Extensive grassland management; may support bank stabilization by maintaining grasslands and reducing erosion.<br>• DZ-0407: Land management in Natura 2000 areas; may support river area exclusion, passive restoration, and floodplain reconnection by restricting intensive land use and promoting natural restoration. |
| Greece | 10/8 | • Π1-31.2, Π1-31.3, Π1-31.10: Support biodiversity and landscape restoration; directly support hedgerow planting (€45–€250/ha), riparian vegetation, passive restoration, bank stabilization, pond creation, floodplain reconnection, and flow regime improvement.<br>• Π1-31.4, Π1-31.6, Π1-31.7, Π1-31.9: Promote water quality improvement and sustainable land management; may indirectly support instream habitat improvement and riparian health.<br>• Π1-31.5: Agroforestry support; may reduce erosion and aid channel reconfiguration through improved soil and water management. |
| Hungary | 1/1 | • Agro-Ecological Programme; supports hedgerow planting (€150–280/ha), buffer strips, and nutrient retention, which may aid bank stabilization, ditch management, riparian vegetation enhancement, and passive restoration. Broader biodiversity goals may also support pond creation and floodplain reconnection. |
| Ireland | 1*/3<br>*divided into actions | • Action 1 – Space for Nature; supports pond creation and managed ditches for biodiversity and water quality improvement (€60–€77/ha).<br>• Action 2 – Extensive Livestock Production; may support passive restoration by reducing livestock pressure and enabling riparian recovery.<br>• Action 4 – Planting of Native Trees or Hedgerows; directly supports hedgerow planting (€60–€77/ha), bank stabilization, and native vegetation management along watercourses. |

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TABLE 1 (*Continued*) Summary of eco-schemes with potential relevance for river restoration in the 2023–2027 CAP Strategic Plans across EU Member States.

| Member state | Total number of eco-schemes/ applicable for river restoration | Eco-schemes for river restoration |
|---|---|---|
| Italy | 5/4 | • ECO-1: Animal welfare; may support passive restoration by reducing livestock pressure near rivers.<br>• ECO-2: Ground cover in tree crops; may support bank stabilization and improve instream conditions by reducing erosion and runoff.<br>• ECO-4: Extensive forage systems; may support ditch management, instream habitat improvement, and floodplain reconnection *via* better water retention.<br>• ECO-5: Pollinator support; may enhance river plant management and instream health through hedgerow planting and native vegetation cover.<br>• ECO-3 was excluded due to its narrow, olive-specific focus. |
| Latvia | 6/5 | • TM4.2, TM4.6: Support biodiversity, habitat protection, and water retention; may support bank stabilization, river plant management, passive restoration, pond creation, floodplain reconnection, instream habitat improvement, and minimal flow maintenance.<br>• TM4.4, TM4.5: Focus on soil conservation and nutrient runoff reduction; may support ditch management, bank stabilization, and instream habitat quality.<br>• TM4.7: Organic farming support; may support hedgerow planting, ditch management, pond creation, and instream habitat improvement through nature-based practices. |
| Lithuania | 17*/7<br>*two are inactive | • TI05eko1.5: Landscape element management; supports hedgerow planting, pond creation (€150–€1,329/ha), and bank stabilization *via* riparian vegetation.<br>• TI05eko1.6, TI05eko6: Multi-year management of grasslands and wetlands; may support river plant management, instream habitat improvement, and passive restoration.<br>• TI05eko1.7: Permanent grass strips; may support ditch management, erosion control, and riparian vegetation health.<br>• TI05eko7: Extensive wetland management; directly supports floodplain reconnection (€269/ha), minimal flow maintenance, and may aid channel reconfiguration.<br>• TI05eko9, TI05eko11: Animal welfare and conversion of arable land to meadows; may support passive restoration by reducing livestock pressure and promoting permanent vegetation near rivers. |
| Luxembourg | 8/4 | • 1.02.512: Non-productive areas; may support hedgerow planting, pond creation, ditch management, river area exclusion, instream habitat improvement, floodplain reconnection, and minimal flow maintenance through ecological corridors and habitat features.<br>• 1.02.513: Buffer strips; directly support bank stabilization (€670–1,300/ha) and native river plant protection (~€700–704/ha); may support channel reconfiguration and improve ditch ecosystems.<br>• 1.02.515: Catch crops and undersowing; may support ditch management and erosion control through soil cover and nutrient retention.<br>• 1.02.517: Refuge zones on mowing meadows; may indirectly support passive restoration along riparian zones by limiting disturbance. |
| Malta | 6/3 | • DP ECO-NPE: Non-productive elements on arable land; may support hedgerow planting, buffer strips, ditch management, bank stabilization, passive restoration, and channel reconfiguration through ecological structure promotion.<br>• DP ECO-Biodiversity: Directly supports pond creation (€2,500/ha/year), native vegetation preservation, invasive species removal, hedgerow planting, instream habitat protection, and floodplain reconnection.<br>• DP ECO-IPM: Integrated pest management; may support ditch management by reducing runoff and improving soil drainage. |
| Netherlands | 1/1 | • National Eco-scheme (point-based system); directly supports hedgerow planting and ditch management, and may support bank stabilization, instream habitat improvement, channel reconfiguration, pond creation, river plant management, passive restoration, and floodplain reconnection depending on selected eco-activities. Payment levels vary by bronze, silver, and gold tiers. |

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**TABLE 1** (*Continued*) Summary of eco-schemes with potential relevance for river restoration in the 2023–2027 CAP Strategic Plans across EU Member States.

| Member state | Total number of eco-schemes/ applicable for river restoration | Eco-schemes for river restoration |
|---|---|---|
| Poland | 7/3 | • I 4.5: Water retention on permanent grasslands; may support bank stabilization, channel reconfiguration, ditch management, pond creation, river plant management, and minimal flow maintenance by enhancing infiltration and reducing erosion.<br>• I 4.2: Carbon farming and nutrient management; may support channel reconfiguration and riparian vegetation improvement through nutrient runoff control.<br>• I 4.1: Melliferous plant areas; may support hedgerow planting along field borders or near watercourses. |
| Portugal | 6/4 | • A.3.6: Biodiversity promotion; directly supports hedgerow planting (€26–€376/ha) and passive restoration through livestock exclusion (€60–€86.25/ha); may support river plant management, ditch improvement, pond creation, channel reconfiguration, and fish passage restoration.<br>• A.3.2: Integrated production; may support bank stabilization and ditch management through sustainable land use and reduced chemical inputs.<br>• A.3.3.1: Soil management – permanent pasture; may support bank stabilization, ditch management, and instream habitat improvement through erosion control.<br>• A.3.3.2: Soil management – organic fertilization; may support instream habitat quality by promoting nutrient recycling and reducing pollution. |
| Romania | 5/3 | • PD-04: Environmentally beneficial practices on arable land; may support bank stabilization, hedgerow planting, river plant management, and passive restoration through non-productive elements and buffer zones.<br>• PD-05: Environmentally friendly agriculture in small farms; may support ditch management and water quality protection through low-input farming and reduced runoff.<br>• PD-06: Grass on interrows in fruit plantations and vineyards; may support bank stabilization and ditch management by reducing erosion and sediment movement near water bodies. |
| Slovakia | 2/2 | • 31.1: Whole-farm eco-scheme; may support bank stabilization, hedgerow planting, ditch management, pond creation, river plant management, and instream habitat improvement through soil conservation, buffer strips, and green infrastructure.<br>• 31.2: Animal welfare – grazing; may support river area exclusion, passive restoration, and minimal flow maintenance by reducing grazing pressure near watercourses. |
| Slovenia | 11/5 | • INP08.01, INP08.06: Soil protection and water retention; may support bank stabilization, passive restoration, floodplain reconnection, and minimal flow maintenance by reducing erosion and improving infiltration.<br>• INP08.11: Biodiversity in permanent crops; may support hedgerow planting, pond creation, and floodplain reconnection through habitat improvement.<br>• INP08.05: Ground cover maintenance; may support riparian vegetation and river plant management by reducing erosion and nutrient loss.<br>• INP08.09: Land-use avoidance in sensitive areas; may support passive restoration in riparian zones by reducing disturbance. |
| Spain | 9/4 | • 1PD31001809V1, 1PD31001807V1: Biodiversity enhancement and erosion control; may support bank stabilization, hedgerow planting, pond creation, river plant management, passive restoration, and floodplain reconnection through vegetation cover and habitat connectivity.<br>• 1PD31001803V1, 04V1, 05V1: Soil and water-focused agroecology; may support ditch management by reducing runoff and erosion; irrigated crops scheme (05V1) may support minimal flow maintenance *via* water-use efficiency.<br>• 1PD31001802V1: Extensive grazing and land-use exclusion; may support passive restoration in riparian zones and Mediterranean pasture areas. |

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TABLE 1 (*Continued*) Summary of eco-schemes with potential relevance for river restoration in the 2023–2027 CAP Strategic Plans across EU Member States.

| Member state | Total number of eco-schemes/ applicable for river restoration | Eco-schemes for river restoration |
|---|---|---|
| Sweden | 3/3 | • MellanFångVår: Cover crops and spring tillage; may support bank stabilization, ditch management, pond creation, and floodplain reconnection by reducing nitrogen runoff and erosion.<br>• EKO: Organic farming; may support hedgerow planting, pond creation, riparian vegetation management, and floodplain reconnection through biodiversity-focused, low-input practices.<br>• Precision: Precision farming; may support channel reconfiguration and riparian vegetation through improved water and nutrient management. |

The asterisk (*) indicates special implementation formats or classification challenges, which vary by country. For example, France's single national eco-scheme is divided into six selectable pathways; other cases may reflect regional schemes or eligibility distinctions.

relevant actions (e.g., wetlands or floodplain management) yet still show limited direct support for connectivity measures. A subset of countries exhibits portfolios dominated by potential and no-support categories, implying that outcomes would depend heavily on where practices are implemented in the landscape. This typology is derived from the category distributions in Figures 2–4 and Supplementary Table S1; it does not rely on the ordinal composite (used solely to order Figure 2). A robust benchmark to the NRR headline (e.g., kilometres of free-flowing rivers restored by 2030) would require pairing these categories with spatial baselines (riparian length, mapped barriers, floodplain extent) and plausible uptake scenarios; we flag this as an avenue for future work.

# 4 Discussion

This study set out to assess the extent to which CAP eco-schemes across EU Member States support river restoration and the protection of blue infrastructure. While the analysis identified a variety of measures with potential ecological benefits, it also revealed substantial variation in ambition, implementation, and effectiveness. The following discussion unpacks these findings in greater detail, examining (i) the marginal role of river restoration in current eco-scheme design, (ii) the prevalence of passive over active interventions, (iii) the influence of national contexts, (iv) structural constraints within the CAP framework, and (v) underused design options. We conclude by reflecting on how future CAP reforms could enhance the strategic alignment of eco-schemes with EU freshwater and biodiversity goals.

## 4.1 River restoration remains marginal in eco-scheme design

This analysis demonstrates that river restoration is currently a marginal and fragmented objective within the CAP eco-schemes designed by EU Member States for the 2023–2027 programming period. While many eco-schemes include agricultural practices that may incidentally benefit freshwater ecosystems, these are rarely framed or intended as river restoration interventions. Instead, support for freshwater-related actions tends to emerge as co-benefits of broader biodiversity, soil conservation, or pasture management schemes, rather than as explicit policy goals.

## 4.2 Categories of support reveal implementation uncertainty

The limited visibility of river restoration becomes even more striking when considering the classification approach used in this study. We applied a broad and inclusive definition of potential support, aiming to capture any plausible link between eco-scheme eligibility and restoration outcomes. However, it is important to emphasize that measures categorized as "potentially supportive" often represent generous interpretations. These actions do not target river restoration directly and may only contribute to it if implemented near water bodies and in ecologically meaningful ways. For example, catch crops, biodiversity-friendly crops, or permanent soil cover can provide negligible benefits to aquatic ecosystems when applied far from riparian zones.

When combining the "potential support" category with measures classified as "not supported", a critical pattern emerges: in most Member States, river restoration is either absent from eco-schemes or addressed only indirectly, with little guarantee of meaningful ecological outcomes. This finding underscores the structural limitations of the current CAP eco-scheme framework in delivering on the EU's freshwater restoration ambitions.

## 4.3 Passive restoration dominates; active interventions are largely absent

The types of restoration actions supported under eco-schemes are also revealing. Passive approaches—particularly the exclusion of livestock from riparian zones—are by far the most common. Across Member States, support for riparian vegetation recovery tends to be embedded within grazing management schemes aimed at promoting extensive livestock systems. This pattern is especially prevalent in Mediterranean countries such as Portugal, Spain, and Greece, where livestock exclusion is treated as a side effect of pastureland regulation rather than an ecological objective in its own right. This pattern is consistent with global evaluations showing that local-scale restoration efforts often fail to produce meaningful biodiversity gains, when disconnected from catchment-scale drivers and stressors (Haase et al., 2025).

In contrast, active restoration measures—such as instream habitat improvement, channel reconfiguration, floodplain reconnection, or fish passage—are virtually absent from national eco-scheme portfolios. This absence reflects both technical and structural constraints: such interventions typically require collective management, hydrological infrastructure, or long-term coordination across properties and jurisdictions. These requirements are not easily accommodated by the annual, farm-level logic that currently defines eco-schemes. This reflects not only technical and economic constraints but also governance and institutional gaps: current CAP design does not sufficiently incentivize or coordinate collective, cross-farm restoration actions, nor does it provide frameworks for integrating agricultural, water, and biodiversity goals.

Beyond these structural limitations, political and administrative factors also play a critical role in shaping the ambition of eco-schemes. Member States often face trade-offs between administrative simplicity and ecological ambition; complex, cross-sectoral measures are politically sensitive and resource-intensive, and some governments prioritise short-term agricultural stability over longer-term ecological gains (Midler et al., 2023). Coordination capacity also varies across countries, affecting the ability to plan and enforce more ambitious schemes in line with water and biodiversity objectives (Flávio et al., 2017; Manzoni et al., 2025). These constraints echo EU-wide 'readiness' challenges for barrier removal under the NRR—gaps in barrier inventories (especially small structures), uneven data, and weak post-removal monitoring—which raise transaction costs and deter structural measures within Pillar I (Darre et al., 2025).

## 4.4 Regional implementation reflects national priorities and landscapes

Despite the overarching CAP framework, Member States interpret and implement eco-schemes in highly context-dependent ways. In Mediterranean countries, freshwater-related support is largely confined to pasture management and erosion control, reflecting both climatic realities and traditional land use. Central and Eastern European countries—including Lithuania, Latvia, and Bulgaria—demonstrate a somewhat broader range of freshwater-relevant measures, sometimes extending to wetland management or floodplain restoration. This may be linked to a higher availability of semi-natural landscapes and national biodiversity priorities.

Western and Northern European countries, such as the Netherlands, Denmark, and Sweden, tend to focus on precision farming, biodiversity scoring systems, and soil management. In these cases, support for river restoration is indirect and embedded within broader sustainability or climate strategies. Overall, these patterns suggest that eco-scheme implementation is strongly shaped by national administrative traditions, farming systems, and ecological baselines.

## 4.5 Eco-scheme structure limits systemic restoration

The scale and operational design of eco-schemes help explain the limited uptake of more ambitious restoration measures. Farm-level actors are more likely to adopt small-scale, low-cost practices that align with existing operations—such as hedgerow planting, pond creation, or riparian buffer maintenance. These interventions offer visible on-farm benefits (e.g., erosion control, pest regulation) and require relatively little investment or coordination.

In contrast, systemic hydrological restoration—such as setting minimum flow requirements or reconnecting floodplains—demands higher upfront costs, long-term planning, and often multi-actor collaboration. These conditions are difficult to meet within the current framework of annual, individual-farm payments. As a result, eco-schemes largely support localized interventions, while landscape-scale ecological needs remain poorly addressed. Farmer-side preferences reinforce these structural limits. Experimental evidence indicates that when farmers must choose, many favour the shorter, more flexible eco-schemes over longer, more restrictive AECM, with strong disutility for complete fertiliser/herbicide bans and a premium on procedural flexibility in result-based contracts. These patterns increase the risk that annual, low-coordination options displace multi-annual, system-level measures unless governance and payment design explicitly counterbalance that tendency (Anougmar et al., 2025). Future reforms should prioritize governance innovations—such as collective implementation mechanisms, landscape-scale planning, and targeted financial incentives—to overcome the limitations of individual-farm schemes and achieve meaningful restoration outcomes.

Examples from established programs show how multi-annual, system-level restoration can be organized and financed. In the United States, the Conservation Reserve Program and state–federal CREP agreements use 10–15-year contracts, annual rental payments, and cost-share to establish riparian buffers and retire sensitive land from production—design features that could inform CAP instruments when longer commitments are required (USDA FSA, 2010; USDA FSA, 2023). In England, Environmental Land Management provides codified watercourse buffer options with multi-year terms and per-hectare payments, a template for targeted support along blue infrastructure (DEFRA, 2024a; DEFRA, 2024b). Beyond farm boundaries, the Murray–Darling Basin's environmental watering framework shows that floodplain reconnection and overbank flows depend on basin-scale governance and multi-year funding rather than annual, farm-level incentives—highlighting why such works sit more naturally in Pillar II and cohesion instruments (Murray–Darling Basin Authority, 2023; Chen et al., 2020). Experience with results-based points systems does not, by itself, resolve the annual-contract constraint that limits hydromorphological works. In the Dutch eco-scheme, payments remain a hybrid (largely effort-linked) due to EU reimbursement rules, and early assessments note that thresholds can be harder to meet for landscape/biodiversity themes—potentially dampening participation in certain landscape types. These features support our conclusion that structural connectivity works require multi-annual, collective instruments, with eco-schemes complementing them through on-farm pressure reduction (Jongeneel and Gonzalez-Martinez, 2023). Expert guidance echoes these structural limits: annual eco-schemes should not substitute for the multi-year commitments needed to restore seminatural features and connectivity; without careful design, short-term options can displace deeper measures. Recommended remedies include multi-annual agreements, progressive/points-based payments, and explicit coherence with AECMs so that simple, annual actions complement—rather than compete with—structural works (Pe'er et al., 2022).

## 4.6 Design options remain underutilized

Although the CAP legal framework allows for the development of collective and multi-annual eco-schemes, these options remain underexploited. Few Member States have designed instruments that explicitly support long-term or cooperative implementation of freshwater restoration. This represents a missed opportunity to better align the scale of intervention with the ecological complexity of river systems. Implementation tools can make flexible menus workable at scale. The Dutch points system uses dynamic scoring across years (re-weighting activities that are over- or under-subscribed) and a farmer simulation tool to preview choices—operational features that could be adapted to target riparian and water-related actions while preserving farmer flexibility (Jongeneel and Gonzalez-Martinez, 2023). Broader experience suggests two design levers are especially underused for freshwater outcomes: collective and coordinated implementation at landscape scale, and spatial targeting to protect and expand non-productive features (e.g., riparian strips, ponds, extensive grassland) that underpin connectivity. Both raise effectiveness beyond farm-by-farm delivery and are explicitly recommended for the post-2023 Green Architecture (Pe'er et al., 2022).

Developing collective schemes targeting riparian zones, stream networks, or shared water bodies could greatly enhance the effectiveness of CAP spending in the freshwater domain. Such schemes would require stronger technical support, governance arrangements, and possibly dedicated funding envelopes—but they remain legally and institutionally feasible within the current CAP. Experience also highlights the interplay with GAEC 8: several countries link eco-schemes to quantitative extensions of non-productive areas (e.g., options to combine conditionality with additional set-aside or landscape features), yet this can raise cognitive load for farmers and increase administrative complexity for paying agencies. Without careful design, such complexity risks depressing uptake in more demanding freshwater-relevant options (Runge et al., 2022). Evidence from Flanders suggests that diversifying contract designs—offering both action- and result-based options with calibrated restrictions and clearer procedural flexibility—can broaden participation across heterogeneous farm types, while keeping pathways open into more ambitious, multi-year measures. In the absence of such tailoring, 1-year eco-schemes may cannibalize participation in AECM without delivering equivalent ecological gains (Anougmar et al., 2025).

Collective delivery is administratively feasible within the CAP where managing authorities enable group applications and landscape-level contracts. Netherlands has implemented this at national scale: certified farmer collectives are the beneficiaries of agri-environment payments and coordinate targeting, enrolment, and local monitoring across members—an operational model that could be extended to freshwater measures (Alblas and van Zeben, 2022; ENRD, 2016). This experience indicates that, with appropriate legal and paying-agency arrangements, collective schemes can be scaled while retaining accountability for outcomes.

## 4.7 Aligning incentives with ecosystem service delivery

For many farmers, restoration of riparian zones, ponds, or riverbanks represents an opportunity to address underproductive areas of their land—provided costs are realistically compensated. Contract attributes shape willingness-to-accept as much as payment levels: in choice experiments, higher compensation increases uptake, but bans on agro-chemicals markedly depress it; flexibility in result-based monitoring (e.g., advance inspection notice) reduces the compensation farmers require. These findings argue for pricing stricter ecological constraints realistically and using procedural flexibility where it does not dilute outcomes, to avoid steering farmers toward only the least demanding options. Without such calibration, eco-schemes' fiscal and administrative appeal may come at the cost of participation in deeper, multi-annual contracts needed for river restoration (Anougmar et al., 2025). Eco-schemes promoting these actions offer ecosystem services such as filtration, soil and sediment retention, carbon storage, pollination, and pest control. While these services are widely recognized at the farm level, they are harder to quantify at landscape or catchment scales, where multiple actors and delayed benefits complicate cost-benefit assessments. Targeted AKIS (advice and training) support is flagged as important to facilitate uptake where designs grow more complex or introduce new practices (Runge et al., 2022).

From an economic perspective, trying to prevent "overcompensation" by relying on average income-forgone benchmarks risks ignoring that intra-marginal rents are an unavoidable feature of market-like provisioning; local price differentiation and, where feasible, objective-specific point prices can improve cost-effectiveness (Jongeneel and Gonzalez-Martinez, 2023). Payment design should avoid crowding out high-impact options: experts recommend lower rewards or exclusion for low-biodiversity actions, ring-fenced budgets for biodiversity-relevant measures, and, where feasible, top-up style remuneration to recognise public-goods delivery above income-forgone benchmarks. Otherwise, "light-green" options can outcompete more demanding measures that deliver riparian and connectivity gains (Pe'er et al., 2022).

These choices reflect real trade-offs. A high share of Pillar I resources remains dedicated to income support, constraining fiscal space for complex ecological contracts and favouring low-risk, easily verifiable actions. Independent assessments note that, while the reformed CAP is "greener than before," Strategic Plans do not yet match EU environmental ambition, underscoring the tendency to prioritise uptake and administrative simplicity over deeper ecological outcomes (ECA, 2024; Midler et al., 2023). A pragmatic division of labour is to keep farm-level eco-schemes focused on ubiquitous practices with clear verification (e.g., riparian buffers, nutrient management) while reserving multi-annual, collective funding streams for structural works (barrier removal, floodplain reconnection) coordinated at catchment scale.

Current eco-scheme payment levels may underestimate the real costs of implementing effective restoration. A clearer and more realistic cost framework—adapted to different types of interventions—should be developed by Member States to ensure adequate uptake and delivery of public goods.

## 4.8 Ecological framing and performance indicators are needed

To improve ecological impact, river restoration must be framed using concepts from river ecology that recognize the dynamic nature of floodplain systems and their associated blue infrastructure—meanders, oxbows, ponds, canals, and wetlands. Restoration goals should be expressed in concrete, measurable terms, such as habitat area rehabilitated, channel length reprofiled, or populations of target species supported. Indicator sets should also reflect readiness needs highlighted for barrier removal—coverage of small barriers, basin-scale connectivity metrics, and before/after ecological monitoring—so that CAP tracking contributes directly to NRR delivery (Darre et al., 2025).

Financing and enforcement of indicators can build on systems already in place. Since 1 January 2023, Member States operate an Area Monitoring System (AMS) using Copernicus Sentinel data for continuous checks, embedding satellite-based verification into paying-agency controls and enabling proportionate, risk-based field audits (European Commission: Directorate-General for Communication, 2023; Luketić et al., 2022). Commission Checks-by-Monitoring guidance and quality-assurance protocols provide the technical backbone, while operational services such as Sen4CAP/CAP Area Monitoring Services lower marginal costs by leveraging EU-funded, open satellite data (Luketić et al., 2022; Copernicus, n.d.). These tools allow routine verification of spatial indicators—e.g., riparian buffer width, vegetation persistence, and seasonal management windows—while concentrating field inspections on high-risk cases. Several administrations already planned to leverage remote sensing and geo-referenced photo evidence for compliance (e.g., Poland), which aligns with CAP Checks-by-Monitoring and can lower verification costs for spatial indicators such as riparian buffer width and vegetation persistence (Runge et al., 2022).

Complementing AMS checks, widely used biodiversity and landscape indicators (e.g., Farmland Bird Index, butterfly monitoring, pollinator and plant indicators; extent/quality of seminatural habitats and landscape heterogeneity) can anchor result-oriented tracking of eco-scheme contributions to riparian condition and connectivity, provided data access and resources for monitoring are strengthened (Pe'er et al., 2022).

These indicators should reflect both structural and functional improvements, be time-bound, and, wherever possible, monitored remotely to ensure transparency and cost-efficiency. Integrating remote sensing, geospatial tools, and biodiversity monitoring networks can strengthen adaptive management and allow for better reporting and evaluation.

## 4.9 Toward a coherent EU restoration strategy under the CAP and aligning eco-schemes with NRR delivery

Recent syntheses identify seven persistent challenges for restoring free-flowing rivers in Europe—definitional clarity (free-flowing rivers, barriers, reference areas), network-scale connectivity (longitudinal, lateral, vertical, temporal), meta-ecosystem thinking, outcome-oriented prioritisation, stakeholder engagement, conflicts with sectoral policies (e.g., CAP), and integrated monitoring frameworks (Stoffers et al., 2024). These system-level issues mirror the structural limitations we observe for eco-schemes: annual, farm-level incentives are poorly matched to network-scale connectivity goals, while definitional ambiguity and cross-policy conflicts complicate targeting and delivery. Embedding these considerations into CAP design would improve alignment with NRR implementation (Stoffers et al., 2024; Darre et al., 2025).

The findings of this study highlight a critical gap between the environmental ambitions of the CAP and the specific needs of river and floodplain restoration in agricultural landscapes. While a wide variety of eco-scheme measures exist, their implementation is highly heterogeneous and lacks strategic alignment across Member States. This fragmentation weakens CAP's contribution to EU freshwater goals and limits the scalability of restoration outcomes. From a governance perspective, coherence and complementarity among conditionality, eco-schemes, AECMs, and non-productive investments are preconditions for measurable biodiversity recovery; eco-schemes should operate as an intermediate instrument (scaling ubiquitous practices and non-productive features), while AECMs and investments target quality, multi-year restoration in priority areas. Setting S.M.A.R.T. targets and applying the no-backsliding principle can help align budgets and instruments with restoration outcomes (Pe'er et al., 2022).

External EU-level assessments are consistent with this pattern: CAP Plans are greener than before yet display heterogeneous ambition and limited quantification of restoration-relevant outcomes, implying that eco-schemes alone are unlikely to meet NRR targets without coordinated instruments and clearer monitoring baselines (Perissi, 2025).

To move toward a more effective framework, future CAP reforms should embed river restoration as an explicit objective within eco-scheme design. Member States should be encouraged—or required—to adopt context-adapted but comparable restoration measures, supported by standardized ecological indicators. These may include benchmarks for riparian buffer integrity, aquatic habitat connectivity, or functional biodiversity. A shared set of metrics would enhance policy accountability, enable progress tracking, and foster a common understanding of restoration success in agricultural landscapes. Improved integration between the CAP, the Water Framework Directive, and the Nature Restoration Regulation is critical to ensure land-use policy coherence and enhance the delivery of environmental public goods at landscape scale.

CAP's environmental Specific Objectives—SO4 (climate), SO5 (environmental care), and SO6 (landscapes and biodiversity)—map closely onto NRR restoration aims (Articles 4, 11–13), providing a policy lane to finance measures that benefit freshwater ecosystems. In practice, Result Indicators R21 (Protect water quality), R23 (Sustainable use of water), and R26 (Natural-resources investments) offer immediate "monitoring hooks" for eco-schemes that improve riparian buffers, reduce nutrient and pesticide pressures, or enhance on-farm water retention. By contrast, barrier removal and floodplain reconnection demanded by NRR Article 9 typically require multi-annual, collective action and are better matched to Pillar II/EAFRD and cohesion-policy investments (including irrigation-network upgrades under CAP

Article 74) rather than annual farm-level eco-schemes (Manzoni et al., 2025).

A pragmatic division of labour would (i) use eco-schemes to scale widespread, farm-level practices tracked by R21/R23—e.g., riparian vegetation management, nutrient-management and reduced tillage that cut diffuse pollution—and (ii) channel collective, structural works (barrier removal, floodplain reconnection, canal retrofits) through multi-year Pillar II and cohesion instruments, coordinated within the National Restoration Plan. This aligns with the NRR's requirement that NRPs document the interplay with CAP Strategic Plans and mitigates the delivery risk inherent in the CAP's devolved "new delivery model." (Manzoni et al., 2025).

Eco-schemes alone are unlikely to achieve the NRR's scale of river restoration (e.g., free-flowing river kilometers) or the LULUCF net-removals objective; they primarily target farm-level practices and diffuse pressures, while structural connectivity gains depend on barrier removal, floodplain reconnection, and basin-scale coordination. A practical bridge from our classification to NRR delivery metrics is to pair each support category with spatial baselines (e.g., national inventories of riparian length, mapped small and large barriers, floodplain area at risk) and plausible uptake/eligibility scenarios to derive lower/upper-bound contributions (Darre et al., 2025). Such estimates would then be integrated with Pillar II/cohesion investments for structural works and reported under shared indicators—linking CAP reporting to NRR and LULUCF tracking (European Parliament and Council of the European Union, 2023).

Translating the plan-level intent identified here into implemented restoration requires triangulation with (i) implementing acts and paying-agency circulars that refine eligibility and controls; (ii) realised uptake (hectares/contracts and budget execution); (iii) spatial eligibility layers (e.g., mapped riparian zones, barrier inventories, floodplain extent); and (iv) outputs from the CAP Area Monitoring System and field audits. This evidence is necessary to diagnose synergies/conflicts with other instruments (e.g., water and energy policies) and to quantify contributions to NRR and LULUCF targets (ECA, 2024; Luketić et al., 2022; Midler et al., 2023).

To connect plan-level intent to the NRR free-flowing rivers target, Member States can map each support category to measurable units and budgets: (i) translate direct/indirect/potential actions into spatial units (e.g., km of riparian buffer enhanced, number of barriers addressed, ha of floodplain reconnected) using national riparian, barrier, and floodplain inventories; (ii) construct eligibility/uptake scenarios to derive lower/upper-bound contributions by 2030 and beyond; and (iii) align financing accordingly by earmarking eco-scheme envelopes for riparian protection and diffuse-pressure reductions (tracked under R21/R23), while channeling structural connectivity works (barrier removal, floodplain reconnection) through multi-annual Pillar II/EAFRD and cohesion instruments (tracked under R26), coordinated within National Restoration Plans. This pragmatic split recognises eco-schemes' complementary role, ensures that legal targets are also financially supported, and enables transparent progress tracking *via* CAP performance and AMS-enabled verification.

Looking ahead to 2030 and 2050, the composition of support categories is sensitive to policy adjustments and uptake trajectories. Under a *status quo* pathway, portfolios would likely remain dominated by passive, farm-scale practices, with limited change in direct support for connectivity. An accelerated pathway—tightening eligibility to riparian zones, earmarking payments for on-water and riparian actions, enabling group contracts, and coupling eco-schemes with multi-annual investments (e.g., barrier removal, floodplain reconnection)—would tend to shift measures from potential to indirect, and in some cases to direct support. A delayed pathway—administrative backlogs, budget constraints, or weak targeting—would keep portfolios static, with outcomes contingent on where practices happen to be implemented. These trajectories describe reclassification between categories over time, not a cardinal change in performance, and they underscore that near-term gains to 2030 will hinge on targeted eligibility and coordination, while 2050 outcomes depend on deeper instrument design (e.g., multi-year, collective contracts for hydromorphological measures).

Because the composite score is ordinal and used only for display (Figure 2), country ordering should not be read as a cardinal ranking of policy performance; the central result is the low prevalence of direct support and the dominance of potential/no-support categories across Member States.

## 4.10 Conclusion

This study provides an EU-wide assessment of how river restoration is addressed through CAP eco-schemes in the 2023–2027 programming period. Despite the CAP's increasing focus on environmental sustainability, our findings reveal a persistent gap between ambition and implementation when it comes to freshwater systems. River restoration remains a marginal objective in most eco-scheme portfolios, with support largely confined to passive, farm-scale practices—such as hedgerow planting or livestock exclusion—that offer only limited ecological outcomes when implemented in isolation.

More ambitious restoration actions, including instream improvements and hydrological reconnection, are virtually absent from national designs. These gaps reflect deeper structural limitations: eco-schemes are currently shaped by annual payments, individual-farm targeting, and underused legal options for collective and multi-annual coordination. As a result, opportunities to restore blue infrastructure—ponds, canals, riparian buffers, and floodplains—remain largely untapped.

To close this gap, future CAP reforms should prioritise three key shifts: (i) embed explicit restoration goals within eco-scheme design, including targets for riparian and aquatic habitats; (ii) scale up collective and multi-annual eco-schemes to enable cross-farm coordination; and (iii) adopt standardised ecological indicators—such as riparian buffer width, aquatic connectivity, and habitat condition—supported by robust remote and field-based monitoring. Aligning CAP, NECP/LULUCF and NRR reporting—using consistent, measurable criteria—will be essential to convert greening on paper into verifiable restoration outcomes (Perissi, 2025).

Aligning agricultural policy with the spatial scale, cost structure, and ecological complexity of river restoration is essential to ensure the CAP delivers on its environmental objectives. A recent synthesis of freshwater governance challenges (van Rees et al., 2025) underscores the need for improved coordination, monitoring, and funding alignment—issues that mirror the findings of this study. We do not claim sufficiency relative to NRR or LULUCF targets; instead, our classification provides a foundation for quantitative scaling by linking support categories to NRR-aligned metrics (e.g., riparian kilometres, barrier removal candidates, floodplain hectares) and to LULUCF-relevant carbon outcomes in subsequent analyses. Looking forward, a coherent EU-wide framework for river restoration in agricultural landscapes—anchored in shared goals, minimum criteria, and performance-based support—can transform eco-schemes from fragmented tools into strategic levers for systemic ecological recovery.

## Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

## Author contributions

LPDS: Conceptualization, Data curation, Investigation, Writing – original draft. SB: Funding acquisition, Project administration, Validation, Writing – review and editing. MF: Conceptualization, Supervision, Validation, Writing – review and editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Publisher's note



## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenvs.2025.1681757/full#supplementary-material

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