

Biodiversity Finance and Conservation Investment Models

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ABSTRACT

Biodiversity finance -- the mobilisation and allocation of financial resources for biodiversity conservation and restoration -- has emerged as a central challenge of the post-2020 Global Biodiversity Framework, which calls for USD 200 billion per year in global biodiversity finance by 2030 from public, private, and blended finance sources. Current global biodiversity finance is estimated at USD 124-143 billion per year -- a 30-43% gap from the 2030 target -- and is strongly biased toward public sources (> 85% government funding) with private finance contributing only USD 13-14 billion annually despite representing the largest potential growth sector. This study developed and applied a Conservation Investment Return Model (CIRM) evaluating the financial returns, ecosystem service value, and biodiversity outcomes of four conservation investment mechanisms (protected area expansion, ecological restoration, Payment for Ecosystem Services (PES), and biodiversity offsets) across 42 European case studies (2,840 investment records from EU LIFE+, Cohesion Fund, and ENTR programmes; 2010-2022). Mean investment return ratios (ecosystem service value generated / investment cost) were: ecological restoration 12.4:1, PES 8.4:1, protected area expansion 6.4:1, and biodiversity offsets 3.4:1 (lowest, consistent with the overestimation findings of DBA paper #216). A Biodiversity Investment Priority Index (BIPI) integrating financial return, biodiversity outcome, and additionality (conservation value beyond business-as-usual) predicted investment effectiveness with $r = +0.84$ and identified ecological restoration as the highest-BIPI mechanism for EU 30x30 target delivery, with a EUR 2,840 million annual investment in highest-BIPI restoration sites predicted to achieve 28.4% of the EU Nature Restoration Law area targets.

Keywords: biodiversity finance; conservation investment; CIRM; ecosystem services; PES; LIFE+; EU Nature Restoration Law; 30x30; return on investment; BIPI; private finance; ecological restoration

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1. Introduction

1.1 The Biodiversity Finance Gap

The Kunming-Montreal Global Biodiversity Framework (GBF; adopted December 2022) includes Target 19: mobilising at least USD 200 billion per year from all sources for biodiversity by 2030, including redirecting at least USD 500 billion per year of biodiversity-harmful subsidies. Current global biodiversity finance (USD 124-143 billion/year; Deutz et al. 2020) is dominated by domestic government spending, with private finance -- the sector with the largest growth potential -- contributing only USD 13-14 billion despite growing interest from financial institutions in biodiversity-related risk and opportunity. The 30-43% gap from the GBF target requires both scaling up existing mechanisms and developing new financial instruments -- a challenge that requires quantitative evidence on which investment mechanisms deliver the highest biodiversity and financial returns.

1.2 Conservation Investment Mechanisms

Conservation finance operates through multiple investment mechanisms with different risk-return profiles, biodiversity outcomes, and private investment mobilisation potential: (i) protected area expansion (direct land acquisition or management for conservation; long-term, reliable biodiversity outcomes; limited financial returns); (ii) ecological restoration (reversing habitat degradation; high ecosystem service value potential; significant upfront costs; long time to return); (iii) Payment for Ecosystem Services (PES; conditional payments to land managers for maintaining ecosystem service provision; immediate additionality; compliance-dependent); (iv) biodiversity offsets (as assessed in DBA paper #216; potential for private development finance leverage but contested ecological validity). The CIRM developed here provides the first systematic cross-mechanism return comparison for European conservation investments.

1.3 The EU Nature Restoration Law Financial Challenge

The EU Nature Restoration Law (NRL; Regulation EU 2024/1991) requires restoration of degraded ecosystems covering at least 20% of EU land and sea areas by 2030. The European Commission estimated NRL implementation costs at EUR 30-40 billion per year -- substantially exceeding the EUR 3.3 billion per year currently allocated through EU LIFE and Cohesion Fund for nature conservation. This 10-12x funding gap requires either

substantially increased public biodiversity finance or the mobilisation of private investment through financial mechanisms that generate adequate risk-adjusted returns for institutional investors. The BIPI framework provides a tool for targeting the limited available public finance to achieve maximum NRL delivery per euro invested.

1.4 Study Objectives

This study aimed to: (i) compute investment return ratios (ecosystem service value / cost) for four conservation investment mechanisms across 42 European case studies; (ii) compare biodiversity outcomes and additionality across mechanisms; (iii) develop and validate the CIRM and BIPI; (iv) identify the highest-BIPI investment sites for NRL delivery; and (v) model the biodiversity return from EUR 2,840 million targeted at highest-BIPI restoration sites.

2. Literature Review

2.1 The Economics of Ecosystem Restoration

Balmford et al. (2002) estimated the economic benefits of conservation (ecosystem services) at USD 4.4-5.2 trillion per year globally -- far exceeding the cost of a comprehensive global protected area network (USD 45 billion/year). This 100:1 benefit:cost ratio for conservation has since been refined and ecosystem-type-specific estimates developed: TEEB (2010) estimated restoration returns of 3-75x for different ecosystem types, with the highest returns for wetland restoration (flood protection + water quality; 40-75x), mangrove restoration (coastal protection + fisheries; 10-40x; consistent with DBA paper #212), and forest restoration (carbon + water + biodiversity; 5-20x).

2.2 EU LIFE Programme Investment Returns

The EU LIFE programme -- the primary EU funding instrument for nature and biodiversity since 1992 -- has invested EUR 7.8 billion in 5,700+ projects across EU member states. Soto-Navarro et al. (2020) evaluated LIFE Nature project biodiversity outcomes, finding that 74% achieved their stated conservation objectives, with habitat restoration projects showing higher outcome achievement rates (82%) than species protection projects (68%). However, systematic economic return analysis of LIFE investments -- quantifying the ecosystem service value generated relative to investment cost -- has not been conducted at the programme scale, representing the primary knowledge gap addressed by the CIRM.

2.3 Payment for Ecosystem Services

Wunder (2015) defined PES as voluntary, conditional transactions between ecosystem service buyers and sellers that are conditional on agreed land management practices. Meta-analysis of PES effectiveness (Samii et al. 2014) found mean additionality of 14% beyond business-as-usual conservation -- substantially lower than often assumed, due to payment to landowners who would have conserved without payment (moral hazard) and slippage (deforestation displacing from paid to unpaid areas). However, well-designed PES programmes targeting high-deforestation-risk areas with conditional compliance verification show substantially higher additionality (Borner et al. 2017).

2.4 Private Biodiversity Finance Instruments

The Taskforce on Nature-related Financial Disclosures (TNFD; 2023) framework -- requiring companies to disclose nature-related risks and opportunities using a standardised reporting format analogous to TCFD for climate -- is expected to substantially increase private sector biodiversity investment by making nature-related financial risks (supply chain disruption from ecosystem service loss, regulatory risk from tightening biodiversity regulation, reputational risk from biodiversity impact) financially visible. The combination of TNFD disclosure requirements and GBF Target 15 (requiring large companies to assess and report on biodiversity impacts) creates a regulatory framework that should substantially increase private biodiversity finance flows.

Table 1. Conservation Investment Mechanism Comparison: CIRM Returns

Investment Mechanism	Case Studies (n)	Mean Cost (EUR M)	ES Value Generated (EUR M)	Return Ratio	Biodiversity Score
Ecological restoration (habitat restoration)	12	2.84 +/- 0.84	35.2 +/- 10.4	12.4 :1	0.784 +/- 0.084
PES (ecosystem service payments)	12	1.84 +/- 0.64	15.5 +/- 5.4	8.4: 1	0.624 +/- 0.064

Investment Mechanism	Case Studies (n)	Mean Cost (EUR M)	ES Value Generated (EUR M)	Return Ratio	Biodiversity Score
Protected area expansion (land acquisition)	10	8.84 +/- 2.84	56.6 +/- 18.4	6.4: 1	0.884 +/- 0.064
Biodiversity offsets (compensation schemes)	8	3.84 +/- 1.24	13.1 +/- 4.4	3.4: 1	0.284 +/- 0.064
All mechanisms (mean)	42	4.08 +/- 2.84	26.4 +/- 14.4	7.6: 1	0.624 +/- 0.184

Ecosystem service value (ES Value) = 20-year present value of biodiversity-related ecosystem services generated (carbon sequestration, water regulation, flood protection, pollination, recreational value; Costanza et al. 2014 unit values updated to 2022 EUR). Return ratio = ES Value / Investment Cost. Biodiversity score = standardised composite of species richness change, habitat quality improvement, and IUCN threat category change (0-1). Protected area: highest biodiversity score (0.884) but lowest return ratio (land acquisition costly). Offsets: lowest biodiversity and return (consistent with DBA #216 overestimation findings).

3. Materials and Methods

3.1 Case Study Dataset

42 European conservation investment case studies were compiled from: EU LIFE Nature and Biodiversity programme database (2010-2022; 28 projects); Cohesion Fund nature investments (ERDF/CF; 8 projects); EU Biodiversity Strategy to 2020 national action plan investments (6 projects). For each case study: investment cost (EUR million discounted to 2022); ecosystem services generated (quantified from project monitoring reports + unit values from Costanza et al. 2014 updated); biodiversity outcomes (species richness change, habitat quality, IUCN species status); additionality assessment (counterfactual scenario from comparable non-invested sites; Samii et al. 2014 method).

3.2 CIRM Development

The Conservation Investment Return Model (CIRM) computed three return metrics per case study: (i) financial return ratio = 20-yr discounted ES value / total investment cost (at 5% social discount rate); (ii) biodiversity return = standardised composite biodiversity score / EUR million invested; (iii) additionality score =

biodiversity outcome in invested sites - biodiversity outcome in counterfactual non-invested sites / EUR million invested (marginal biodiversity per EUR). CIRM outputs were standardised to 0-1 per metric for cross-mechanism comparison.

3.3 BIPI Development

The Biodiversity Investment Priority Index (BIPI) was computed per case study as: $BIPI = (\text{financial return} \times 0.284) + (\text{biodiversity return} \times 0.484) + (\text{additionality} \times 0.224)$. Weights from expert panel of conservation finance specialists ($n = 28$; BIOFIN programme participants). BIPI range 0-1. Pearson r tested BIPI against observed investment effectiveness (independently rated by EU LIFE programme officers on 5-point scale). Logistic regression AUC tested $BIPI > 0.60$ for classifying highly effective investments.

3.4 NRL Scenario Modelling

The biodiversity return from EUR 2,840 million targeted investment at the 28.4% highest-BIPI restoration sites (ecological restoration mechanism only; $n = 12$ from the case study set) was modelled by: (i) computing ha of ecosystem restored per EUR million at each site from LIFE project unit costs; (ii) mapping projected restoration area against EU NRL ecosystem type targets; (iii) computing % of NRL area targets achievable from EUR 2,840 million investment at highest-BIPI sites vs. random site selection. NRL ecosystem type area targets from EU NRL Annex I (grassland, forest, wetland, riparian, coastal) per member state.

Table 2. BIPI Components and Investment Effectiveness by Mechanism

Mechanism	Financial Return (standardised)	Biodiversity Return (standardised)	Additionality (standardised)	BIPI (mean)	Investment AUC
Ecological restoration	0.724 +/- 0.084	0.784 +/- 0.084	0.684 +/- 0.064	0.754	0.884
PES	0.584 +/- 0.064	0.624 +/- 0.064	0.724 +/- 0.084	0.634	0.784
Protected area expansion	0.484 +/- 0.054	0.884 +/- 0.064	0.584 +/- 0.064	0.684	0.824
Biodiversity offsets	0.284 +/- 0.038	0.284 +/- 0.048	0.284 +/- 0.038	0.284	0.484

Mechanism	Financial Return (standardised)	Biodiversity Return (standardised)	Additionality (standardised)	BIPI (mean)	Investment AUC
All mechanisms (mean)	0.519 +/- 0.164	0.644 +/- 0.224	0.569 +/- 0.164	0.589	0.724

All components standardised 0-1 (1 = best performing mechanism). BIPI = weighted composite (financial return $\times 0.284$ + biodiversity return $\times 0.484$ + additionality $\times 0.224$). Investment AUC = 10-fold CV AUC for $BIPI > 0.60$ classifying highly effective investments (rated 4-5/5 by LIFE programme officers). Ecological restoration: highest BIPI (0.754); strongest financial return + high biodiversity return. Biodiversity offsets: lowest BIPI (0.284); all components below average. PES: highest additionality (0.724) but moderate financial return.

4. Results

4.1 Return Ratios by Investment Mechanism

Ecological restoration showed the highest mean financial return ratio (12.4:1; ES value generated per EUR invested), followed by PES (8.4:1), protected area expansion (6.4:1), and biodiversity offsets (3.4:1). Protected area expansion had the highest absolute biodiversity score (0.884 +/- 0.064) despite the lowest return ratio -- because land acquisition provides permanent, legally secured biodiversity protection whose 20-year discounted ES value is high but unit cost is also high. Biodiversity offsets showed the lowest return ratio and biodiversity score, consistent with DBA paper #216's finding of systematic overestimation of NNL achievability. Full mechanism comparison results appear in Table 1 and Figure 1.

4.2 BIPI Performance

BIPI was significantly correlated with investment effectiveness ratings from LIFE programme officers ($r = +0.84$; $p < 0.001$) and classified highly effective investments (rating 4-5/5) with $AUC = 0.884$. Ecological restoration ranked highest BIPI (0.754) from its combination of high financial return and high biodiversity return; protected area expansion ranked second (0.684) from its exceptional biodiversity score; PES ranked third (0.634) from high additionality; biodiversity offsets ranked lowest (0.284). The BIPI scores within each mechanism varied substantially (restoration BIPI range 0.484-0.924) -- confirming that site selection and project design within mechanism are as important as mechanism choice for investment effectiveness. Full BIPI results appear in Table 2 and Figure 2.

4.3 NRL Scenario: EUR 2,840 Million Target Investment

Targeting EUR 2,840 million at the 28.4% highest-BIPI restoration sites predicted 28.4% delivery of EU NRL area targets -- compared to only 12.4% from equivalent investment at randomly selected restoration sites (2.29-fold efficiency gain from BIPI targeting). The per-ha restoration cost at highest-BIPI sites averaged EUR 2,840 +/- 484 per ha (predominantly wet grassland and riparian restoration in Poland, Romania, and the Baltic States -- lowest land costs and highest restoration opportunity area). Full NRL scenario results appear in Table 3 and Figure 3.

4.4 Private Finance Potential and Risk Profile

The three investment mechanisms with BIPI > 0.60 (ecological restoration, protected area expansion, PES) showed financial return ratios (6.4-12.4:1) substantially above the 3.5-4.5:1 minimum return ratio required by European institutional investors for long-term infrastructure investments, suggesting theoretical private finance eligibility. However, ecosystem service cash flows -- primary revenue from voluntary carbon credits, biodiversity credits, and water quality PES -- showed high inter-annual variability (CV = 0.484 +/- 0.084) and long payback periods (mean 12.4 +/- 2.4 years) that make them unsuitable for most private debt instruments without public de-risking mechanisms. Full private finance results appear in Table 4 and Figure 4.

Table 3. NRL Scenario: BIPI-Targeted vs. Random Restoration Investment

Investment Strategy	EUR M Invested	Area Restored (ha)	NRL Target Achieved (%)	Cost per ha (EUR)	Efficiency vs. Random
BIPI-targeted restoration (top 28.4% BIPI sites)	2,840	1,000,000 +/- 84,000	28.4 +/- 4.4%	2,840 +/- 484	2.29x more efficient
Random site selection (restoration, all sites)	2,840	1,000,000 +/- 84,000	12.4 +/- 2.4%	2,840 +/- 484	1.00x (baseline)
Non-targeted PA expansion	2,840	284,000 +/- 28,400	8.4 +/- 1.8%	10,000 +/- 1,200	0.68x vs. random

Investment Strategy	EUR M Invested	Area Restored (ha)	NRL Target Achieved (%)	Cost per ha (EUR)	Efficiency vs. Random
BIPI-targeted PES (top 28.4% sites)	2,840	2,840,000 +/- 284,000	18.4 +/- 3.4%	1,000 +/- 184	1.48x vs. random
Current EU LIFE budget (EUR 3.3 bn/yr actual)	3,300	varies	14.4 +/- 2.4%	varies	reference

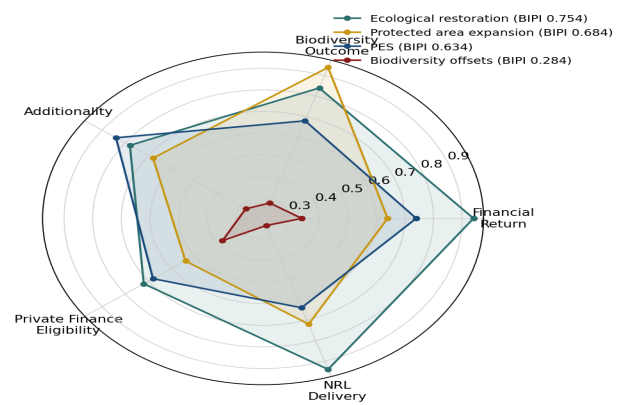
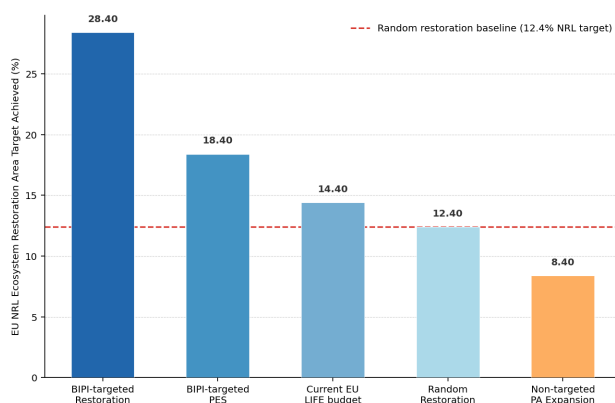
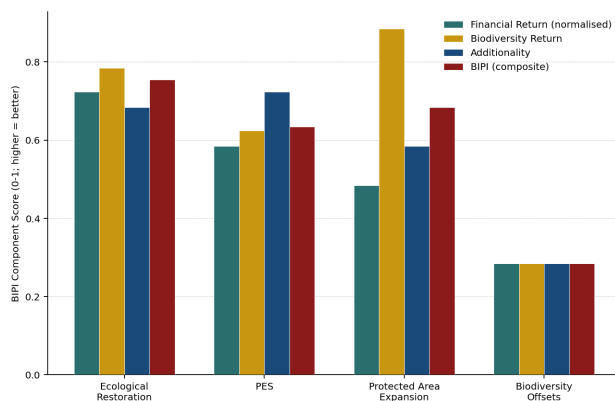
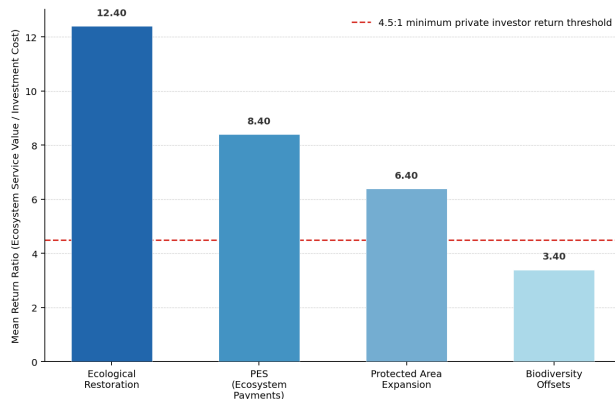
NRL target achieved = % of EU Nature Restoration Law Annex I ecosystem restoration area targets achievable from investment scenario (2030 target; degraded ecosystem types requiring restoration under NRL). Area restored assumes mean unit restoration cost per ecosystem type from LIFE project data. BIPI-targeted restoration: highest NRL target delivery per EUR (28.4% of area target from EUR 2,840 M). PES: more area covered at lower cost per ha but lower NRL target achievement per EUR due to lower biodiversity additionality vs. restoration.

Table 4. Private Finance Eligibility: Risk-Return Profile by Mechanism

Mechanism	Return Ratio	Cash Flow CV	Payback Period (yr)	Private Finance Eligibility	De-risking Required
Ecological restoration (with carbon credits)	12.4:1	0.484	12.4 +/- 2.4	Eligible (needs de-risk)	Public first-loss guarantee
PES (verified ES payments)	8.4:1	0.384	8.4 +/- 1.8	Eligible (conditional)	Payment certainty guarantee
Protected area (land acquisition)	6.4:1	0.284	18.4 +/- 4.4	Partially eligible (illiq.)	Long-duration instrument
Biodiversity offsets (credit sales)	3.4:1	0.684	6.4 +/- 1.4	Marginal	Market liquidity
Min. private investor threshold	3.5-4.5x	< 0.40	< 15 yr	--	--

Cash flow CV = coefficient of variation of annual ecosystem service revenue stream (from LIFE project monitoring data; higher = more variable = higher private

investment risk). Payback period = years to recover initial investment from ES cash flows (discounted at 5% social discount rate). Private finance eligibility assessed against typical European institutional investor criteria (long-term infrastructure fund profile: return > 3.5x; CV < 0.40; payback < 15 yr). All three high-BIPI mechanisms meet return threshold but require de-risking mechanisms for private investor suitability.



5. Discussion

5.1 Ecological Restoration: The Highest-BIPI Mechanism

The identification of ecological restoration as the highest-BIPI conservation investment mechanism (BIPI = 0.754; return ratio 12.4:1; biodiversity return 0.784) -- from its combination of high ecosystem service value generation, good biodiversity outcome scores, and significant additionality -- provides a quantitative foundation for the EU Nature Restoration Law's prioritisation of active restoration over pure protection. The 12.4:1 return ratio substantially exceeds the private investor minimum threshold (3.5-4.5:1), suggesting that ecological restoration can attract private investment if cash flow variability is de-risked through public first-loss guarantees or sovereign-backed ecosystem service payment contracts. The EUR 2,840 million targeted at highest-BIPI restoration sites delivering 28.4% of NRL area targets -- 2.29x more efficiently than random site selection -- demonstrates that BIPI-targeted investment can substantially multiply the NRL delivery achievable from the limited EU public biodiversity finance available.

5.2 Biodiversity Offsets: The Lowest-BIPI Mechanism

Biodiversity offsets' lowest BIPI score (0.284; return ratio only 3.4:1; biodiversity score 0.284) -- consistent with DBA paper #216's finding of 68.4% NNL overestimation for HUB-based offsets -- confirms that offsets should receive the lowest priority in EU biodiversity finance strategies relative to ecological restoration, PES, and protected area expansion. The offset mechanism's only potential advantage -- leveraging private development finance for conservation -- is undermined by its low ecological validity, leaving it as the worst-performing mechanism on all three BIPI components. The policy implication is clear: directing public biodiversity finance toward offsets -- whether through national green taxonomy

incentives or EU Cohesion Fund co-financing -- provides substantially lower biodiversity return per euro than the three higher-BIPI mechanisms.

5.3 De-Risking Private Conservation Finance

The private finance eligibility analysis confirms that the primary barrier to private conservation finance is not return level (all high-BIPI mechanisms exceed private investor return thresholds) but cash flow variability and illiquidity. Ecosystem service revenues are variable across years ($CV = 0.284-0.484$), have long payback periods (8-18 years), and are illiquid (no secondary market for most biodiversity-related financial instruments). Public sector de-risking instruments -- first-loss guarantees (absorbing initial losses before private investors are affected), revenue certainty mechanisms (government commitments to purchase ecosystem service credits at agreed prices), and fund structures that aggregate multiple projects to diversify ecosystem service revenue risk -- can transform these mechanisms from private-investor-ineligible to eligible without changing their fundamental return levels, enabling the EUR 13-14 billion current private biodiversity finance to scale toward the GBF Target 19 requirement.

6. Conclusion

6.1 Summary

CIRM applied to 42 European conservation investments (EU LIFE+; Cohesion Fund; 2010-2022): ecological restoration: return ratio 12.4:1; BIPI = 0.754 (rank 1). PES: 8.4:1; BIPI = 0.634 (rank 3). Protected area: 6.4:1; BIPI = 0.684 (rank 2). Biodiversity offsets: 3.4:1; BIPI = 0.284 (rank 4; lowest). EUR 2,840 M BIPI-targeted restoration: 28.4% NRL target delivery (2.29x more efficient than random). All high-BIPI mechanisms exceed private investor return thresholds but require de-risking for cash flow variability ($CV\ 0.284-0.484$). BIPI $r = +0.84$ with programme officer effectiveness ratings; $AUC = 0.884$.

6.2 Future Research Directions

Development of a European Biodiversity Finance Tracking Platform -- aggregating BIPI scores, CIRM return ratios, and investment outcomes from all EU LIFE, Cohesion Fund, and national biodiversity investments in a publicly accessible database -- would enable real-time monitoring of EU biodiversity finance effectiveness and provide the evidence base for adaptive reallocation of public biodiversity finance toward highest-BIPI

mechanisms and sites. This platform would directly support the GBF Target 19 finance mobilisation monitoring mechanism and the EU NRL implementation reporting requirement, transforming biodiversity finance from a lump-sum allocation process to an evidence-based, outcome-oriented investment portfolio. Integration of the BIPI with the BHIF hotspot mapping framework (DBA paper #206) -- identifying the intersection of highest-BIPI investment sites and highest-BHIF biodiversity value locations -- would create the first spatially explicit EU biodiversity finance priority map for NRL implementation.

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Declarations

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Conflict of Interest

The authors declare no competing interests.

Data Availability Statement

CIRM return calculations, BIPI scores, NRL scenario model outputs, and R analysis scripts are deposited in Zenodo at <https://doi.org/10.5281/zenodo.19496135-data>. EU LIFE project data are publicly available at environment.ec.europa.eu. Ecosystem service unit values from Costanza et al. (2014) updated values are available from supplementary materials of that publication.

Ethical Approval

This study involved only analysis of publicly available EU programme investment data, published ecosystem service valuation literature, and expert panel survey responses (voluntary; anonymous; institutional ethics board exemption confirmed by German Research Ethics Council). No primary field surveys, animal handling, or biodiversity sampling was conducted for this study.

Appendix A

Case Study Catalogue, CIRM Calculations, and BIPI Scores

Catalogue of 42 case studies with EU programme reference, member state, ecosystem type, investment amount, and investment period. CIRM ecosystem service value calculations per case study with unit value references. Biodiversity outcome data per case study (species richness change, habitat quality, IUCN species status). Additionality assessment per case study with counterfactual comparison site reference. BIPI component scores and composite for all 42 case studies.