

Nature-Based Solutions for UK Flood Resilience

GREEN FUTURES SOLUTIONS

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University of Exeter

Santander

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Glossary of Terms

Abbreviation	Meaning
AEP	Annual Exceedance Probability
CaBA	Catchment-Based Approach
CCC	Climate Change Committee
Defra	Department for Environment, Food and Rural Affairs
EA	Environment Agency
ECB	European Central Bank
EIB	European Investment Bank
ELS	Entry Level Stewardship
ESG	Environmental, Social and Governance
EUR	Euro (currency)
FCERM	Flood and Coastal Erosion Risk Management
FLOW	Swiss Re "FLOW" parametric water-level insurance product
GHOST	GHOST model (hydrological model referenced in the text)
HLS	Higher Level Stewardship
KPI	Key Performance Indicator
MRV	Monitoring, Reporting and Verification
NAO	National Audit Office
NbS	Nature-Based Solutions
NERC	Natural Environment Research Council
NEIRF	Natural Environment Investment Readiness Fund
NFM	Natural Flood Management
NPL	Non-Performing Loan(s)
OECD	Organisation for Economic Co-operation and Development
PRA	Prudential Regulation Authority
RP	Return Period
SME	Small and Medium-sized Enterprise(s)
SOC	Soil Organic Carbon
SuDS	Sustainable Drainage Systems
TCFD	Task Force on Climate-related Financial Disclosures
TNFD	Taskforce on Nature-related Financial Disclosures
UK	United Kingdom
UKCP18	UK Climate Projections 2018
USGS	United States Geological Survey
WWNP	Working With Natural Processes

Executive Summary

This report assesses the role of Nature-based Solutions (NbS) as a climate-risk management tool for flood resilience in the UK, with specific relevance to Santander's mortgage, SME, and regional lending exposure. It examines where NbS deliver measurable risk reduction, where their limitations apply, and what conditions are required for NbS to function as credible resilience infrastructure rather than isolated environmental projects.

This report evaluates the effectiveness of NbS in reducing flood risk at the catchment scale and identifies the design principles that distinguish successful, high-impact interventions from those that underperform. It assesses the financial implications of NbS for asset values, insurance affordability, SME resilience, and correlated portfolio risk, while examining the governance, partnership, and data frameworks required to scale NbS credibly across the UK. The analysis synthesises evidence on NbS performance across soil management, land-use change, floodplain restoration, and flow-attenuation measures, supported by practical case studies that illustrate delivery models and their financial relevance. It further explores insurance dynamics, under-insurance exposure, and risk-transfer mechanisms, and identifies systemic constraints, research gaps, and monitoring needs that currently limit private-sector engagement. The report concludes with strategic recommendations to support Santander's risk strategy, partnership development, and the integration of resilience-aligned finance.

Climate change, land-use change, and ecological degradation are intensifying flood risk and wider systemic exposure across the UK. More frequent and intense rainfall, saturated soils, and compound events are increasing damage to homes, businesses, and infrastructure. These impacts are financially material: they influence mortgage collateral values, SME cashflow and default risk, insurance affordability and availability, and regional concentration risk. Traditionally, flood management is often focused on protecting individual assets, such as a single property or piece of infrastructure. However, flooding usually occurs across entire river catchments, meaning that many homes, businesses, and infrastructure systems are affected at the same time. This makes flooding a system-scale risk, where impacts are interconnected across landscapes and portfolios rather than confined to individual locations.

This report finds that NbS provide a practical, cost-effective mechanism to reduce physical risks by restoring the natural processes that regulate water. Interventions such as floodplain reconnections, wetland creation, riparian woodlands, peatland rewetting, regenerative agriculture, soil structure improvement, and slow runoff attenuate flood peaks, increase infiltration and storage, stabilise slopes, improve water quality, and deliver additional co-benefits for biodiversity, carbon, urban cooling, and wellbeing. Crucially, NbS help reduce correlated losses across portfolios by lowering hazard frequency and severity across landscapes rather than protecting individual assets in isolation.

A central conclusion is that catchments are the appropriate organising unit for flood-risk reduction and the delivery of NbS. Catchment-scale partnership models enable coordination between land managers, communities, regulators, delivery bodies, water companies, insurers, and the finance sector. Where such coordination exists, NbS can meaningfully shift flood probabilities; where it does not, interventions often remain too small or fragmented to deliver downstream risk reduction.

The report also clarifies the role and limits of soil management. Soil health interventions can improve infiltration and storage, but their flood-peak benefits are partial and context-dependent, especially during extreme rainfall and when soils are already saturated. Their most significant value lies in their integration with wider catchment measures. Significantly, constraints on scaling soil-based NbS are driven less by "lack of evidence" and more by policy appraisal, fragmented governance, and narrow metrics that fail to capture cumulative catchment benefits.

Insurance dynamics reinforce the case for upstream risk reduction. Flood risk is increasingly reflected in premiums, exclusions, and potential withdrawal. At the same time, under-insurance among SMEs means flood losses can rapidly increase lender balance-sheet risk through arrears or business failure. Parametric insurance models offer promise but depend on improved catchment data and trigger modelling. NbS do not replace insurance; they support insurability by reducing underlying risk.

Despite strong public-sector programmes and a growing evidence base, private finance involvement remains limited, mainly due to gaps in Monitoring, Reporting and Verification (MRV), inconsistent baselines, limited whole-life performance data, and a lack of mechanisms to aggregate projects to investable scale. Across NbS databases, formal monitoring is often absent, limiting investor confidence and the ability to link NbS outcomes to decision-grade financial risk metrics.

NbS should be treated as core climate-risk infrastructure, not a discretionary sustainability activity. Santander can play a catalytic role by using its lending reach and convening power to align land managers, local authorities, delivery partners, insurers, and investors around shared catchment outcomes. This can reduce correlated losses, stabilise asset values and insurance conditions, strengthen customer resilience, and support alignment with evolving expectations on climate- and nature-related risk management.

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Why this matters now: Rising flood risk and systemic exposure

Climate change, land-use change, and rapid urbanisation are intensifying multiple climate-related hazards across the UK, including fluvial and pluvial flooding, drought, heat stress, coastal erosion, and water-quality crises. These pressures rarely act in isolation. Instead, they compound and interact with ecological tipping points - thresholds at which gradual environmental degradation can trigger abrupt, non-linear, and potentially irreversible shifts in system behaviour. Examples include the transition of drained peatlands from carbon sinks to carbon sources, the collapse of salt marshes under sustained sediment deficit and sea-level rise, and the desiccation of upland catchments that reduce baseflows and amplify summer drought risk (Lenton et al., 2019[1]; Armstrong McKay et al., 2022[2]). Once crossed, these thresholds can significantly elevate both environmental and financial exposure, with recovery either extremely costly or technically unfeasible.

UKCP18 climate projections reinforce the urgency of addressing these risks. They show a marked increase in the frequency and intensity of extreme precipitation events, greater variability in seasonal rainfall, and heightened likelihood of compound flooding where high river flows, saturated soils, storm surges, and heavy rain coincide (Met Office, 2019[3]). These trends mean traditional, asset-by-asset risk assessments are no longer sufficient. Instead, UK landscapes require catchment- and system-scale resilience strategies that reduce hazard exposure at source, slow water flow through landscapes, and build adaptive capacity into land-use systems.

NbS offer a scientifically validated suite of interventions that deliver exactly such system-wide benefits. Measures such as soil restoration, woodland creation and riparian buffers, wetland and floodplain reconnection, peatland rewetting, and coastal habitat restoration (including saltmarsh and seagrass recovery) can reduce runoff generation, attenuate flood peaks, stabilise slopes, cool urban environments, buffer coasts against storm energy, and improve water quality. In agricultural landscapes, regenerative practices enhance soil carbon, water retention, and drought and heat resilience. In towns and cities, green–blue infrastructure mitigates surface-water flooding, reduces the urban heat island effect, and improves air

[1] Lenton, T. M., Rockström, J., Gaffney, O., Rahmstorf, S., Richardson, K., Steffen, W. & Schellnhuber, H. J. (2019). Climate tipping points - too risky to bet against. Nature, 575, 592–595. Available here: https://www.nature.com/articles/d41586-019-03595-0

[2] Armstrong McKay, D. I., Staal, A., Abrams, J. F., Winkelmann, R., Sakschewski, B., Loriani, S., Fetzer, I., Cornell, S. E., Rockström, J. and Lenton, T. M. (2022). Exceeding 1.5°C of global warming could trigger multiple climate tipping points. Science, 377(6611), eabn7950. Available here: https://www.science.org/doi/10.1126/science.abn7950

[3] Met Office / UK Centre for Ecology & Hydrology (2019). UK Climate Projections 2018 (UKCP18) Science Overview Report. Met Office Hadley Centre, Exeter, UK. Available here: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index

quality (Burgess-Gamble et al., 2018[4]). Importantly, these interventions not only manage symptoms of climate risk but also strengthen the underlying ecological processes that maintain long-term resilience.

For a bank with an extensive UK lending portfolio, such as Santander, these mechanisms translate directly into reduced physical climate risk and improved asset stability. Investing in NbS also delivers social benefits by improving environmental health and access to nature and reducing the mental health burden of flood-related incidents. Properties, infrastructure, agricultural businesses, and Small and Medium-sized Enterprises (SMEs) located in landscapes benefiting from practical NbS experience lower exposure to flooding, erosion, soil degradation, heat stress, and water scarcity. This reduces the likelihood of loan impairment, protects long-term asset value (NGFS, 2023[5]), and supports clients' transition planning and regulatory alignment. More strategically, integrating NbS considerations into risk assessment also positions Santander within an emerging financial landscape in which climate- and nature-related tipping risks are material to creditworthiness, insurance pricing, and regulatory scrutiny (OECD, 2022[6]; University of Exeter, 2024[7]). In this context, supporting and financing NbS is not only an environmental contribution but also a forward-looking risk management strategy aligned with the future shape of the UK economy.

Climate change, flood risk, and systemic exposure in the UK

Rainfall trends across the UK are rising (see **Error! Reference source not found.**), placing increasing pressure on land that must simultaneously deliver housing growth, food production, flood defence, and nature recovery. These demands are intensifying at a time when climate change and ecological degradation are already constraining the capacity of landscapes to absorb and regulate water. As highlighted by Lloyds Banking Group (2024), land is increasingly required to perform multiple, and sometimes competing, functions within a rapidly changing climate context.

[4] Burgess-Gamble, L., Ngai, R., Wilkinson, M. E., Nisbet, T. R., Pontee, N. I., Harvey, R., Kipling, K., Addy, S. & Rose, S. C. (2018). Working with natural processes – evidence directory. Environment Agency, Bristol. (WWNP Evidence Directory). Available here: https://assets.publishing.service.gov.uk/media/6036c5468fa8f5480a5386e9/Working_with_natural_processes_evidence_directory.pdf

[5] Network for Greening the Financial System (NGFS). (2023). Conceptual Framework for Nature-Related Financial Risks. NGFS. Available at: https://www.ngfs.net/system/files/import/ngfs/medias/documents/ngfs-conceptual-framework-nature-risks.pdf

[6] OECD (2022). Climate Tipping Points: Insights for Effective Policy Action. Organisation for Economic Co-operation and Development, Paris. Available here: https://www.oecd.org/content/dam/oecd/en/publications/reports/2022/12/climate-tipping-points_9994de90/abc5a69e-en.pdf

[7] University of Exeter (2025). Global Tipping Points Report 2023/24: From Scientific Risk to Policy Action. University of Exeter Global Systems Institute. Available here: https://wwflac.awsassets.panda.org/downloads/gtp_summary_report_2025-v4-pages-lo-res--1-.pdf

From a risk perspective, this trajectory poses a growing systemic challenge. More frequent and intense rainfall events increase surface runoff, overwhelm drainage and river systems, and amplify the probability and severity of flooding affecting homes, businesses, and infrastructure (Fowler et al., 2021[8]). These impacts also translate into high economic costs for households, businesses, insurers, and public infrastructure. Current estimates suggest that flooding causes expected annual damages of approximately £1.1 billion in the UK, with projections indicating that these costs could rise to between £2.1 billion and £12 billion per year by the 2080s under climate change scenarios (Sayers et al., 2015[9]).

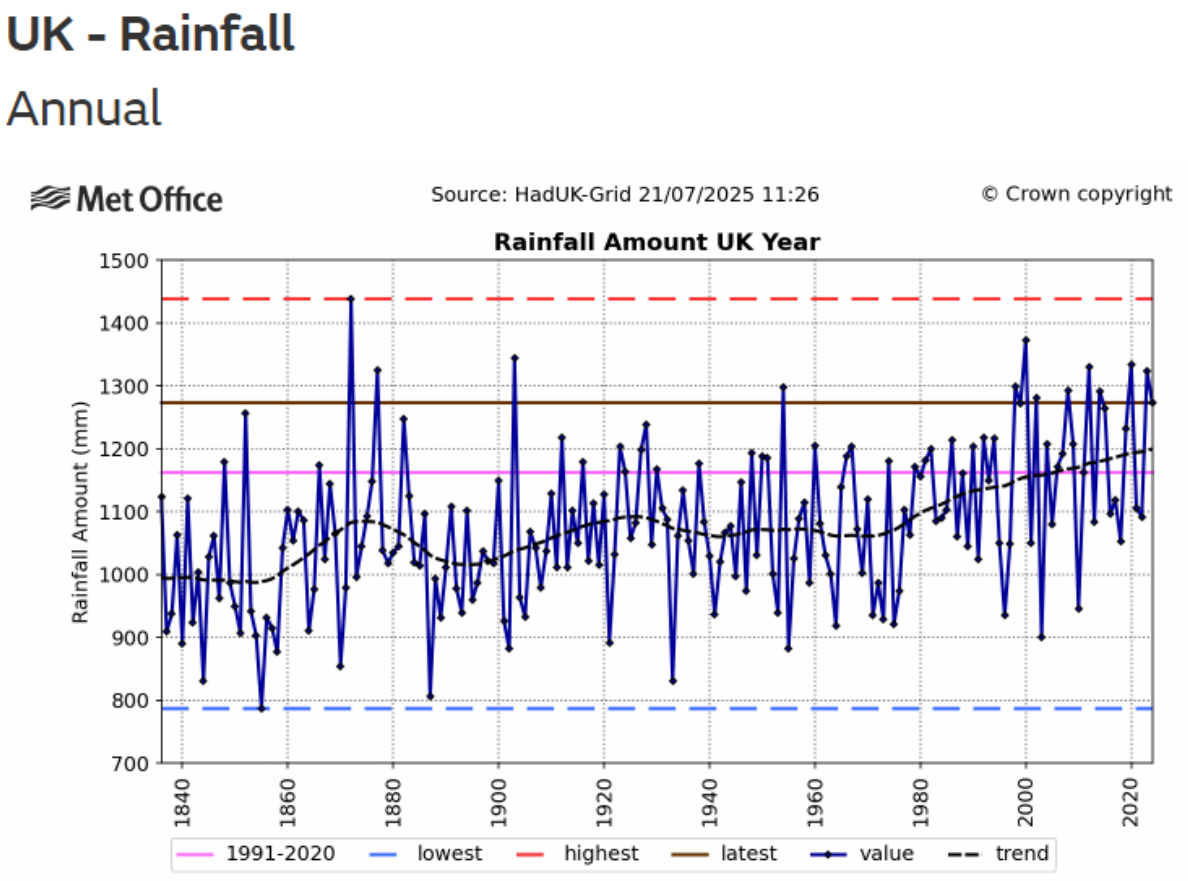

Figure 1: UK Annual Rainfall[10]

[8] Fowler, H. J., Lenderink, G., Prein, A., et al. (2021). Anthropogenic intensification of short-duration rainfall extremes. Nature Reviews Earth and Environment, 2, 107–122. https://doi.org/10.1038/s43017-020-00128-6

[9] Sayers, P., Horritt, M., Penning-Rowsell, E., and McKenzie, A. (2015). Climate Change Risk Assessment 2017: Projections of future flood risk in the UK. Committee on Climate Change. Available here: https://www.theccc.org.uk/wp-content/uploads/2015/10/CCRA-Future-Flooding-Main-Report-Final-06Oct2015.pdf.pdf

[10] Timeseries chart of annual UK mean absolute temperature 1884-2024. The trend is represented by a black dashed line, the 1991-2020 average is shown in pink, and the highest and lowest values in the series are shown by the red and blue dashed lines, respectively. The 2024 value is represented by the horizontal brown line. Source: Met Office

Evidence from the insurance sector highlights the scale of this challenge. Studies suggest that climate change has already increased UK flood losses by approximately 6% between approximately 1990 and 2020, and losses could be about 8% above historical levels by mid-century if global warming reaches about 1.8 °C (Bates et al.,2023[11]). This relationship highlights the non-linear nature of climate risk: relatively small increases in global temperature can lead to disproportionately large increases in domestic flood exposure. Left unaddressed, this trend threatens the long-term affordability of insurance, the resilience of mortgage and SME portfolios, and the viability of existing approaches to flood risk management.

Against this backdrop, investment in NbS is increasingly recognised as essential. By working with natural processes through interventions such as improved soil management, wetland restoration, woodland creation, and floodplain reconnection, NbS can reduce runoff, slow water movement through catchments, and enhance landscapes' capacity to store water. Crucially, these approaches offer the potential to address flood risk while also supporting food security, biodiversity recovery, carbon sequestration, and wider environmental objectives.

Without a shift towards such integrated, nature-based approaches, the current trajectory of rising flood exposure driven by climate change is unlikely to be sustainable environmentally, socially, or financially. This creates a clear imperative for coordinated action across land management, policy, and finance to embed NbS within the UK's long-term flood resilience strategy.

Why partnership is fundamental

Much of the evidence on NbS emphasises the interlinkages among benefits that accrue to different groups, because healthy ecosystems provide multiple ecosystem services. An entire catchment to be positively managed for nature requires the involvement of many partners, landowners, and decision-makers. Working with rather than against complexity appears to be the way to bear dividends; one survey of NbS this year found that urban (and very often water-focused) NbS projects tended to work best in conditions of decentralised policy making, where citizen participation is built in, because these factors lead "to both innovation and additionality in design, quality, biodiversity, multi-functionality and co-benefits" (Petersen et al 2025[12]).

[11] Bates, P. D., Savage, J., Wing, O., Quinn, N., Sampson, C., Neal, J., & Smith, A. (2023). A climate-conditioned catastrophe risk model for UK flooding. Natural Hazards and Earth System Sciences, 23, 891–908. Available here: https://nhess.copernicus.org/articles/23/891/2023/

[12] Petersen, CJ, Russel, DJ, Jensen, A et al. (2025). Evaluation of innovative policy for nature-based solutions: analysis from three European city case studies. Discover Cities, 2, 48. Available here: https://doi.org/10.1007/s44327-025-00083-1

The defining characteristic of NbS interventions is partnership. The multiple and complex needs of regulators and authorities, investors and businesses, and landowners and farmers must be addressed for long-term success (NbS timescales usually see benefits accruing to all these actors over many years). 'Slow the Flow' schemes typically involve communities, regulators, landowners, scientists, actuaries and many others[13]. Through such ways of working, real results are beginning to show; the Slow the Flow project at Pickering, Yorkshire, has reduced the chance of the town flooding from 25% to less than 4% in any given year[14].

In December 2025, the Deputy Directors of Research and Evidence at the Environment Agency (EA) discussed the central importance of NbS within their strategy[15]. They pointed out that investing in nature is, by definition, an investment in long-term capital gains, and something that financial sector partners should readily comprehend. In response, according to the Technical Director of Nature Services at Mott MacDonald[16] The ask from industry and investors to regulators, in order to affect this investment, must be to share the risk assessment and make aligned, joint decisions. Only a delivery approach rooted in partnership and collaboration can unlock the evidence that the private sector demands.

Working in partnership is also a requirement to address one of the other reasons – beyond incentives to invest (see below) - that is slowing the scaling of NbS, namely a lack of skills and approaches for transferring knowledge across institutions. Delivering NbS often requires an innovative 'blended' approach, combining technical expertise and knowledge resources which are often located across different organisations, or sometimes lacking. In the UK, a basic lack of understanding about NbS remains a 'significant barrier' to effective adoption, with hesitations about efficacy leading to 'status quo bias' among policymakers and engineers responsible for flood management[17].Additionally, technical skills among volunteers, landowners and community groups are another key barrier, again leading to hesitation around adopting new practices. The wider adoption of NbS challenges traditional ways of working and may be constrained by a lack of awareness about the opportunities, and a reluctance among property owners and developers to adopt novel solutions[18]. Future NbS projects could benefit from funding supplementary education programmes and demonstrations, which improve skills for delivery and help overcome the hesitance barrier.

[13] Forestry Commission web page. Available here: https://www.forestresearch.gov.uk/research/slowing-the-flow-at-pickering/slowing-the-flow-at-pickering-about-the-project/#news,-presentations-and-site-visits
[14] Written evidence (2016) is the official parliamentary submission summarising outcomes, modelling, and impacts on flood frequency and risk reduction. Available here: https://committees.parliament.uk/writtenevidence/68982/pdf/#:~:text=By%20reducing%20and%20slowing%20the,further%20reduce%20the%20flood%20risk.
[15] Personal communication, December 2025
[16] Personal communication, December 2025
[17] WWF (2025) Nature-Based Solutions in the UK: Case Studies on Overcoming Barriers. Chausson, A., Watters, F., Lee, L., Wilson, R., Crabb, J., and Smith, A. Available here: https://www.wwf.org.uk/sites/default/files/2025-11/Nature-based-Solutions-in-the-UK-WWF-November-2025.pdf
[18] Lloyds Banking Group. (2024). Working with nature: integrating nature-based solutions across urban environments and landscapes. Available here: https://www.lloydsbankinggroup.com/assets/pdfs/who-we-are/financing-a-green-future/working-with-nature-report.pdf

Ecological implications

Because soils are both an integral part of many habitat types and ecosystems in their own right, to gain an ecological understanding of the scope for interventions focusing on soil management or flood risk mitigation we need to consider a wide range of activities including tree planting, arable practices, heathland and peatland management, as well as projects directly addressing freshwater flow, runoff and riverine structure.

From an ecological perspective, the potential of NbS that focus on soil and/or flood management to support nature recovery objectives raises many unknowns. While most of the measures for catchment-wide approaches to freshwater management - including tree planting, installation of log structures, creation of temporary storage ponds, removal of flood embankments and re-meandering - indicate positive impacts, there are significant gaps in the ecological knowledge that should be addressed (Stafford et al 2021[19]). These include:

- reliable modelling to move from relatively small catchments, and upscale to larger systems;
- the impact of 'slow and filter' runoff attenuation approaches;
- assessing the impact of tree planting on flood flows (while some tree planting methods slow surface water flows, they can also have a negative impact on filtration and groundwater recharge);
- the challenge to develop a 'wholescale' approach of linked natural environmental and socio-economic systems from uplands to the sea;
- how to manage conflicting impacts across multiple ecosystem services, for example, planting at scale may result in displacing other land uses and disturbing existing carbon stocks.

Implications for the financial sector

In one recent report from within the banking sector, a survey of eight case studies found that high-quality NbS are often cost-effective compared to alternative, traditional 'grey' built infrastructure, and noted that, nonetheless, only 17% of the finance for NbS comes from the private sector (Lloyds Banking Group, 2024[18]). The private sector is not investing in NbS, but it must, because the finance gap required to meet the UK's nature-related outcomes is £56bn over the next decade[20]; a calculation made five years ago.

[19] Stafford, R, Chamberlain, B, Clavey, L, Gillingham, PK, McKain, S, Morecroft, MD, Morrison-Bell, C and Watts, O. (Eds.) (2021). Nature-based Solutions for Climate Change in the UK: A report by the British Ecological Society. London, UK. Available here: https://www.britishecologicalsociety.org/wp-content/uploads/2022/02/NbS-Report-Final-Updated-Feb-2022.pdf

[20] Green Finance Institute, Effect and Rayment Consulting Services. (2021). The finance gap for UK nature: Assessing the finance gap for nature-related outcomes across the UK and the devolved administrations (Final report 1 October 2021). Green Finance Institute. Available here: https://www.greenfinanceinstitute.com/wp-content/uploads/2025/03/The-Finance-Gap-for-UK-Nature-13102021.pdf

Investment in NbS means finding buyers for ecosystem services. UK farming is becoming more comfortable with the concept of 'farming nature', or carbon, as much as farming food. With the right partnership, the correct intervention and the right buyers, Natural Flood Management (NFM) can work by paying farmers to store water on their land, in different ways (an approach exemplified by the Water Net Gain project[21]).

Evidence from practice

The economic benefits from nature are very widely held - if not fully public - goods and services, for things like air quality, biodiversity, and the living environment. Farmers, landowners and developers underinvest in NbS because they receive only a (often very small) proportion of these enormous benefits. They are poorly incentivised, struggling to afford NbS financing that can reward them for their provision (Lloyds Banking Group 2024[15]); this, combined with subsequent free rider problems, fragmented stakeholders, and the multiple difficulties of ascribing value at different stages, has driven a cycle of underinvestment.

As the British Ecological Society has pointed out, because returns and benefits take a long time to accrue and require monitoring and surveying, and because the systems are complex and ecological services are multiple, filling this data gap requires broad partnerships. Multiple actors need to collaborate to create the evidence needed to incentivise decision-making: evidence of profitability that is robustly quantified, more tangible, and better disseminated (Biasin et al., 2024[22] ; Stafford et al., 2021[19]).

Therefore, what investors and land management decision-makers both need is the same: benefit-demonstrating evidence syntheses that show how mutual gains, both financial and ecological, can underpin reduced flood risk.

Catchments as the organising unit for flood risk and NbS delivery

The partnership approach to NbS is exemplified by the Catchment-Based Approach [23] (CaBA), a community engagement-led framework designed to bring together all the actors required to deliver sustained improvements to England's water environment. CaBA operates at the scale of river catchments, recognising that flood risk, water quality, and ecosystem health are shaped by cumulative land-use decisions made across entire landscapes rather than by isolated interventions.

By convening third-sector organisations, land managers and farmers, local communities, water companies, and government regulators, CaBA provides a governance structure capable of coordinating action across sectors and administrative boundaries. This

[21] Westcountry Rivers Trust. Water Net Gain. (n.d.). Available here: https://wrt.org.uk/project/water-net-gain/
[22] Biasin, A, Toxopeus, H, Pettenella, D, Polzin, F & Masiero, M. (2024). Financing Urban Nature-Based Solutions (NBS): a literature review from funders' perspective. Nature-Based Solutions, 6, 100195. Available here: https://www.sciencedirect.com/science/article/pii/S2772411524000867?via%3Dihub
[23] Catchment-Based Approach (CaBA). (n.d.).Available here: https://catchmentbasedapproach.org/

collaborative model enables locally tailored solutions that reflect the specific hydrological, ecological, and socio-economic characteristics of individual catchments, while also supporting alignment with national policy objectives.

Through its partnerships, CaBA has developed a suite of shared tools, datasets, and mapping resources that document the location, type, and extent of Nature-Based Solutions deployed for NFM across England. These resources help to delineate where interventions are already in place, identify gaps and opportunities for further action, and support more strategic targeting of measures at the catchment scale. Importantly, they also provide a common evidence base for public authorities, delivery partners, and financial institutions to improve coordination, assess cumulative impacts, and support the scaling of NbS in a way that is credible, transparent, and aligned with long-term flood risk reduction goals.

The role and limits of soil management in flood risk reduction

Of 6,200 NFM interventions in England, 333 relate directly to arable and pastoral soil management[24]. However, runoff management and peatland restoration interventions, to give two other examples, are also likely to include soil management.

Soil management interventions can help store surface water and reduce the height of flood peaks. Still, they are more geared toward increasing groundwater recharge (the rate at which water can infiltrate the ground and replenish subsurface aquifers). Calculating the scale of this benefit is hard; estimating the volume of water lost from the surface to groundwater is not feasible. Instead, proxies for impact are used, for example, the percentage of a project's area over which such infiltration is increased. Evidence of the effects of soil improvements on reducing flood peaks remains weak, but Natural Environment Research Council (NERC)-funded research has suggested that such losses to groundwater could be increased by around 20% through 'good' soil management[25].

In our analysis of what works, as evidenced by the UK's Flood and Coastal Erosion Risk Management (FCRM) (see Case Studies section), the solutions for better soil lie in changing farming practices. Such changes are superficially simple but involve changing long-standing practices - and taking on additional risks in what are commonly family businesses – so that in truth they will not happen unless socio-economic complexities are worked with, and not against (Wagner et al, 2023[26]).

While evidence indicates that soil health interventions can improve infiltration, storage, and hydrological functioning, their impact on flood risk reduction is inherently partial and highly

[24] Catchment-Based Approach (CaBA). (n.d.). NFM Hub.(n.d.). Available here: https://nfmhub.catchmentbasedapproach.org/
[25]Catchment Based Approach (CaBA) (2024) NFM Hub Handbook (Version 1.7). Available here: https://catchmentbasedapproach.org/wp-content/uploads/2024/11/NFM-Hub_Handbook_V1.7.pdf
[26] Wagner, M, Waterton, C and Norton, L. (2023). Mob grazing: a nature-based solution for British farms producing pasture-fed livestock. Nature-Based Solutions, 3. Available here: https://www.sciencedirect.com/science/article/pii/S277241152300006X

context-dependent. Importantly, current funding constraints do not primarily reflect a lack of scientific evidence, but rather conservative policy assumptions and the limited integration of soil-based benefits into catchment-scale flood risk frameworks. Soil interventions are typically assessed in isolation, despite functioning most effectively when combined with wider measures such as floodplain reconnection, wetland restoration, woodland creation, and flow attenuation structures. The barrier to scaling soil-based NbS is therefore not evidentiary, but institutional, arising from fragmented appraisal processes, narrow cost–benefit metrics, and policy structures that fail to capture cumulative catchment-scale risk reduction.



The Financial Relevance of Nature-Based Solutions

NbS are increasingly recognised as among the most cost-effective, scalable, and resilient approaches to managing climate and environmental risks. For financial institutions such as Santander UK, the implications are clear and material. Climate-related hazards, such as flooding, soil erosion, heat stress, drought, and declining ecosystem health, directly influence the probability of loan default, the depreciation of mortgaged assets, and the long-term viability of small and medium-sized enterprises (SMEs). In the UK, studies show that properties exposed to flood risk can experience persistent price reduction, reflecting the impact of climate hazards on real estate values as mortgage collateral (Clayton et al, 2021[27]). These risks accumulate across portfolios, exposing lenders to systemic financial instability. By contrast, strategic investment in NbS such as catchment restoration, afforestation, peatland rewetting, regenerative agriculture, and urban green–blue infrastructure helps to reduce hazard exposure at source, slow the flow of water through landscapes, increase soil stability and infiltration, and improve the resilience of local economies. These mechanisms translate into more stable asset values, lower insurance volatility, and expanded opportunities for green finance and sustainability-linked lending.

In the UK, **expected annual flood damages are estimated to be around £2 billion**, with extreme flood years generating significantly higher losses (Bates et al., 2023[11]). UKCP18 projections show that **winter rainfall could increase by up to 30% by 2080**, raising the likelihood of fluvial and pluvial flooding, groundwater emergence, and multi-hazard events. For lenders, this creates a systemic exposure that extends well beyond individual properties. A single severe flood can devalue thousands of homes, disrupt business continuity for hundreds of SMEs, damage critical infrastructure, and trigger clusters of non-performing loans across a region. Insurance markets are already signalling strain: premiums in high-risk areas are rising (Flood Re, 2023[28]), exclusions are increasing, and an expanding number of households and businesses may soon find themselves under-insured or uninsurable (Flood Re, 2023[29]).

At the same time, current UK policy trajectories risk exacerbating financial exposure. This trend is reinforced by recent evidence that around 1 in 9 homes built between 2022 and 2024 are already located in areas at risk of flooding (Aviva, 2026[30]). The UK Government's commitment to deliver 1.5 million new homes by 2029 is not sufficiently aligned with long-term

[27] Clayton, J., Devaney, S., & Sayce, S. (2021). Climate Risk and Real Estate Prices: What Do We Know? Journal of Portfolio Management – Real Estate Special Issue. Available here: https://www.semanticscholar.org/paper/Climate-Risk-and-Real-Estate-Prices%3A-What-Do-We-Clayton-Devaney/fafbc7dafaf44c182a724f2b3d3a188ab16cced9

[28] Flood Re (2023) Insurance affordability – before and after Flood Re. Available at: https://www.floodre.co.uk/wp-content/uploads/Blog-Post-Affordability-and-prices-before-and-after-Flood-Re.pdf?

[29] Flood Re (2023). Flood Re a Broker's guide. Available at: https://www.floodre.co.uk/wp-content/uploads/20759_Brokers12pp-2023-v1-KW.pdf

[30] Aviva (2026). The proportion of new homes built in flood areas rises to one in nine. News on the Aviva web page. Available at: https://www.aviva.com/newsroom/news-releases/2026/02/proportion-of-new-homes-built-in-flood-areas-rises-to-one-in-nine/

flood resilience or land-use planning reform. Recent national analyses indicate that if development continues under current patterns and without stronger planning safeguards, over 100,000 of these new homes could be built in Flood Zone 3. In England, flood risk is classified by the Environment Agency through the National Planning Policy Framework into a series of Flood Zones[31] based on the annual probability of flooding. Flood Zone 3 represents land with the highest level of risk, defined as having a 1% or greater annual probability of river flooding (≥1 in 100 years) or a 0.5% or greater annual probability of sea flooding (≥1 in 200 years). It is further subdivided into Flood Zone 3a (high probability) and Flood Zone 3b (functional floodplain), the latter representing areas where water is expected to flow or be stored during flood events. Other zones include Flood Zone 1 (low probability, <0.1%) and Flood Zone 2 (medium probability, 0.1–1% for rivers).

The highest-risk areas are where annual flooding probabilities exceed 1% for rivers or 0.5% for the sea. Significantly, this would increase future liabilities for lenders, insurers, and homeowners, embedding long-term risk into the UK housing stock. It is also important to note that properties built on or after 1 January 2009 are not eligible for coverage under the UK's Flood Re scheme, increasing the risk that newer homes in flood-prone areas may face higher insurance premiums or become underinsured over time.

This growing exposure is increasingly recognised in national-level assessments of flood risk governance and climate adaptation, which point to a widening gap between development patterns and risk management objectives. These assessments highlight not only rising physical exposure, but also the systemic financial implications for both public finances and private markets, including increased pressure on flood defence spending, insurance affordability, and mortgage risk:

- **Climate Change Committee (2025) –Progress in adapting to climate change**
  Highlights the ongoing construction of homes in high-risk flood zones and criticises the lack of resilience measures in planning decisions.
- **National Audit Office (NAO) (2020) – Managing Flood Risk**
  Documents how developments continue to be approved in flood-prone areas and outlines the long-term implications for public and private finance.

At the same time, current UK policies could exacerbate the problem further, if the UK Government's commitment to provide £1.5 m new homes by 2029 takes precedent over flood resilience. Recent analysis projects that, if current trends continue without policy intervention, more than 100,000 of these new homes will be built on 'flood zone 3' - land with at least 1% chance of flooding each year from rivers or at least 0.5% from the sea[32].

[31] UK Government (2014 – ongoing with updates). Flood risk and coastal change (Table 1 refers to Flood zones in England). Available at: https://www.gov.uk/guidance/flood-risk-and-coastal-change#table1
[32] Carrington, D. (2025). More than 100,000 homes in England could be built in the highest-risk flood zones. The Guardian. Available here: https://www.theguardian.com/environment/2025/feb/08/more-than-100000-homes-in-england-could-be-built-in-highest-risk-flood-zones

Nature-based Solutions deliver a triple dividend that is directly relevant to Santander's UK lending, investment, and risk-management activities:

- **Reduced climate and nature risk**
  By restoring soils, peatlands, floodplains, wetlands, and coastal habitats, NbS reduce hazard exposure at source. They slow runoff, attenuate flood peaks, stabilise landscapes, improve water retention, and buffer coasts against storm surge and erosion. Crucially, they help prevent ecological tipping points such as peatland collapse or saltmarsh loss—that would otherwise trigger abrupt increases in flood risk, carbon emissions, and long-term asset degradation. This moves risk management upstream, beyond property-level defences, toward catchment- and landscape-scale resilience.
- **Enhanced social and economic resilience**
  NbS protect homes, infrastructure, agricultural productivity, and local livelihoods by reducing the frequency and severity of disruptive climate impacts. They support SME continuity, safeguard housing affordability and insurability, and improve community wellbeing through cooler urban environments, cleaner water, and healthier ecosystems. In doing so, NbS help stabilise local economies in regions where Santander has concentrated exposure, reducing correlated losses during extreme events.
- **Positive financial and strategic opportunity**
  NbS create opportunities for Santander to align lending, insurance partnerships, and investment products with climate-resilient and biodiversity-positive outcomes. This includes green mortgages, sustainability-linked loans, blended finance for land-use transition, and support for clients adapting to evolving regulatory and insurance requirements and strategically, integrating NbS into risk assessment and portfolio strategy positions Santander ahead of emerging expectations around climate- and nature-related financial risk, strengthening ESG performance while supporting long-term asset value and creditworthiness.

Homeowners and mortgage holders: protecting assets and affordability

Flooding is a direct financial concern for homeowners and mortgage providers. **Around 6.3 million properties in England are at risk of flooding** from rivers, the sea, or surface water, a figure which is **expected to rise to 8 million (25% of all properties) by 2050** (Climate Change Committee, 2025[33]).

For banks, the material risk is twofold: property devaluation and rising insurance costs.

- **Property value protection:** Homes affected by flooding can lose market value depending on severity and frequency. NbS interventions upstream, such as woodland creation, wetland restoration, or improved soil management, slow down water movement, reducing flood peaks and the likelihood of property damage.
- **Insurance affordability:** Where flood risk is perceived as unmanageable, insurers may increase premiums or withdraw coverage. NbS interventions that demonstrably reduce flood risk can help maintain insurability and protect mortgage affordability for households.
- Wellbeing and social stability: Flood events have well-documented psychological and health impacts. Supporting catchment-scale resilience through NbS aligns with Santander's commitment to community wellbeing and responsible lending.

Hydrological evidence from projects such as Upstream Thinking (South West Water and the Rivers Trust) and Slow the Flow (Calderdale) shows that strategic land-use changes, including cover crops, riparian buffers, and small-scale storage, can reduce peak flow by 10–20 % in local catchments. These effects translate into tangible[34] reductions in property-level flood probability, improving the long-term security of mortgage portfolios.

Flood and Multi-Hazard Exposure and Mortgage Portfolio Stability

Flooded residential properties may experience long-term market value reductions, with studies reporting discounts ranging from around 5% to more than 20%, and in some cases approaching 30%, depending on flood severity, recurrence, and market perceptions of risk (Beltrán et al., 2018[35]). Coastal properties face additional structural risk from sea-level rise and erosion, particularly where protective ecosystems such as dunes, salt marshes, and reefs are degraded. These processes create direct balance-sheet exposure for lenders.

[33] Climate Change Committee (2025). Progress in adapting to climate change: 2025 report. Climate Change Committee, London, UK. Available here: https://www.theccc.org.uk/wp-content/uploads/2025/04/Progress-in-adapting-to-climate-change-2025-1.pdf

[34] Kousky, C., Palim, M., & Pan, Y. (2020). Flood Damage and Mortgage Credit Risk: A Case Study of Hurricane Harvey. Journal of Housing Research, 29(sup1), S86–S120. Available here: https://doi.org/10.1080/10527001.2020.1840131

[35] Beltrán, A., Maddison, D., and Elliott, R. J. R. (2018). Is Flood Risk Capitalised into Property Values? Ecological Economics, 146, 668–685. Available here: https://www.sciencedirect.com/science/article/pii/S0921800916314732?via%3Dihub

NbS that enhance infiltration, slow overland and channelised flow, increase catchment and floodplain storage, or buffer coasts such as woodland creation, riparian buffers, floodplain reconnection, wetland restoration, and coastal habitat restoration have been shown to reduce peak flows and wave energy by significant margins, depending on scale and intervention type (Burgess-Gamble et al., 2018[4]). By mitigating hazards at source and along pathways, NbS helps protect the underlying value of mortgaged assets and reduce the risk of "stranded" properties in high-risk locations.

Insurance affordability and lending viability

High flood- and coastal-risk areas are increasingly associated with escalating insurance premiums and, in some cases, loss of affordable insurance (Flood Re, 2023[28]). As mortgage lending models depend on ongoing insurability and acceptable residual risk, these trends elevate credit and collateral risk for lenders (Bank of England, 2025[36]).

NbS can contribute to maintaining insurability by reducing local and regional flood and erosion risk, stabilising housing markets and supporting mortgage affordability. Where NbS are integrated into community- or catchment-scale adaptation plans, they can underpin new forms of resilience-linked mortgage products that reward risk-reducing investments (e.g. SuDS, property-level protection, local tree planting and urban greening).

Social wellbeing, heat stress, and community stability

Flooding and heatwaves both have well-documented impacts on mental health, physical well-being, and long-term displacement, especially for vulnerable households (Munro et al., 2017[37]). Urban NbS – trees, parks, green roofs, rain gardens and river restoration – can reduce local temperatures, improve air quality, manage surface water, and provide access to nature, thereby improving quality of life.

NbS interventions at the community or catchment scale therefore support broader social sustainability and health co-benefits, outcomes that align with banks' social responsibility commitments and customer wellbeing strategies.

[36] Bank of England (2025). Financial stability report. Available here: https://www.bankofengland.co.uk/-/media/boe/files/financial-stability-report/2025/financial-stability-report-december-2025.pdf

[37] Munro, A., Kovats, R. S., Rubin, G. J., Waite, T. D., Bone, A., Armstrong, B., Beck, C. R., & Amlôt, R. (2017). Effect of evacuation and displacement on the association between flooding and mental health outcomes: a cross-sectional analysis of UK survey data. The Lancet Planetary Health, 1(4), e134–e141. Available here: https://pubmed.ncbi.nlm.nih.gov/28944321/

SMEs and business clients: building resilience into local economies

Small and medium-sized enterprises form the backbone of regional economies but are particularly vulnerable to flood disruptions. According to the Environment Agency, around one in 3[38] SMEs are at risk of flooding and are unable to reopen after a severe flood event. The economic ripple effects, such as lost productivity, supply chain disruption, and reduced employment, affect both local economies and banks' business lending portfolios.

Nature-based interventions deliver measurable benefits for SMEs and their lenders:

- **Business continuity:** Catchment management, soil restoration, and urban green infrastructure reduce downtime and infrastructure damage, protecting income streams and loan repayment capacity.
- **Operational cost savings:** Regenerative agriculture and soil health initiatives improve productivity and reduce input costs (fertilisers, water, and energy), strengthening clients' balance sheets.
- **Resilient supply chains:** By supporting NbS across agricultural and manufacturing landscapes, banks can help safeguard supply chain reliability, a growing ESG consideration for corporate clients.

Economic evaluations by the Department for Environment, Food and Rural Affairs (DEFRA) and the NAO indicate that NbS for flood management yield benefit-to-cost ratios of 3:1 to 5:1 (Sayers,et al., 2025[39]). meaning every pound invested delivers up to nine pounds in avoided losses and ecosystem co-benefits. For Santander's SME clients, particularly in agriculture, construction, and retail, these interventions offer both direct cost savings and enhanced reputational value within sustainable supply networks.

Insurance, data, and the pricing of flood risk

A key mechanism for understanding, costing and potentially funding (see case study 1) NbS around soil management and/or floodwater management is insurance. With inadequate take-up of both business property and business interruption insurance, financial organisations are increasingly looking at parametric insurance services. Payout is typically much quicker, as no damage assessments are required (Swiss Re's 'FLOW' water-level insurance for businesses normally pays out in 21 days[40]).

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[38] Aviva (2021). One in three business properties at risk from flooding, many unprotected from climate risks. Newsroom. Available here: https://www.aviva.com/newsroom/news-releases/2021/09/one-in-three-business-properties-at-risk-from-flooding/

[39] Sayers, P. B., Birkinshaw, S. J., Carr, S., He, Y., Lewis, L., Smith, B., Redhead, J., Pywell, R., Ford, A., Virgo, J., Nicholls, R. J., Price, J., Warren, R., Forstenhäusler, N., Smith, A., & Russell, A. (2025). A National Assessment of Natural Flood Management and Its Contribution to Fluvial Flood Risk Reduction. Hydrological Processes. Available here: https://nora.nerc.ac.uk/id/eprint/540530/1/N540530JA.pdf#:~:text=An%20optimisation%20of%20these%20benefits%20is%20presented,Annual%20Damage%20(EAD)%20to%20residential%20properties%20alone)

[40] Swiss Re Corporate Solutions. (n.d.). FLOW Parametric Water Level Insurance. Available here: https://corporatesolutions.swissre.com/dam/jcr:3b534611-27be-4fc1-b2dd-1e570a9d882a/FLOW-parametric-water-level-insurance.pdf

Only with detailed catchment models in place to determine trigger levels and events, which again requires the financial sector to build models and create new datasets together. In addition, the financial sector has a clear motivation to invest in upstream water management NbS to manage risk transfer. Many actors in this market consider parametric insurance to be vital for climate change adaptation and an inevitably growing solution, but note that risk calculations can only be helpful if they use improved flood risk data[41], and that data is hard – but not impossible – to create in the context of rapid deployment of measures across the UK catchments.

Insurance coverage, under-insurance, and SME vulnerability

Evidence from the UK Government's FCERM research programme highlights a critical vulnerability for SME portfolios: systematic under-insurance in flood-risk areas. Only around half of SMEs hold business property insurance, fewer than a quarter hold business interruption insurance, and less than half of those policies include explicit flood cover (DEFRA,2023[42]). This creates a structural exposure for lenders, as uninsured or under-insured losses are more likely to translate directly into liquidity stress, loan arrears, or business failure following flood events[4].

While comprehensive UK-wide data linking flooding directly to SME non-performing loans (NPLs) remains limited, international evidence and post-event analyses consistently show spikes in loan impairment following major floods, particularly among micro-businesses and location-dependent sectors such as retail, hospitality, light manufacturing, and agriculture (OECD, 2016 [43]; World Bank, 2019 [44]; European Central Bank, 2025 [45]). Flood impacts propagate through lost trading days, damaged stock, disrupted supply chains, and delayed insurance payouts, amplifying short-term liquidity stress and longer-term credit risk.

A further complexity in the UK insurance landscape is the role of Flood Re, the government-backed reinsurance scheme introduced in 2016 to maintain the availability and affordability of household flood insurance. While Flood Re has been effective in stabilising insurance access for high-risk residential properties, it also illustrates the broader tension between affordability and risk transparency. Because premiums within the scheme are capped and partially decoupled from underlying flood risk, the price signal that would normally encourage

[41] Arthur J. Gallagher and Co. / Gallagher Re. (2023). Improving climate resilience with parametric insurance. Retrieved insert date here. Available here: https://www.ajg.com/gallagherre/-/media/files/gallagher/gallagherre/news-and-insights/2023/november/improving-climate-resilience-with-parametric-insurance.pdf

[42] DEFRA. (2023). Review of Affordability and Availability of Flood Insurance to Help Evaluate the Effectiveness of Flood Re (FD2721). Available here: https://randd.defra.gov.uk/ProjectDetails?ProjectId=20448

[43] OECD (2016). Financial Management of Flood Risk. Organisation for Economic Co-operation and Development, Paris. Available here: https://www.oecd.org/environment/financial-management-of-flood-risk-9789264257689-en.htm

[44] World Bank (2019). Lifelines: The Resilient Infrastructure Opportunity. World Bank Group, Washington DC. Available here: https://openknowledge.worldbank.org/handle/10986/31805

[45] European Central Bank (2025). From flood to fire: is physical climate risk taken into account in banks' residential mortgage rates? Available here: https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp3036~43450e2b8f.en.pdf

property-level risk reduction or relocation can be weakened (Surminski,2017[46]). In addition, Flood Re currently applies only to residential properties and excludes most businesses, including SMEs. This creates a structural asymmetry: households in high-risk areas may benefit from subsidised risk transfer, while SMEs operating in the same locations remain exposed to market-priced insurance or, in many cases, remain uninsured. Importantly, the scheme was designed as a temporary transitional mechanism and is expected to phase out by 2039, when the UK flood insurance market is intended to move toward fully risk-reflective pricing (DEFRA, 2023[42]). As this transition progresses, both households and businesses in high-risk areas may face rising insurance costs or reduced availability unless the underlying flood risk declines. In this context, catchment-scale interventions such as NbS could play an increasingly important role in maintaining insurability by reducing physical risk at the source.

In this context, NbS play an indirect but financially material role. By reducing the frequency and severity of flooding at a catchment scale, NbS can help stabilise insurance availability and affordability, which in turn supports SME continuity and debt-servicing capacity (Burgess-Gamble et al., 2018[4]; Swiss Re Institute, 2021[47]). However, NbS alone cannot compensate for low insurance uptake; risk reduction and risk transfer must be treated as complementary rather than substitutable mechanisms (OECD, 2026[48]).

One example is Insure4Nature[49], a UK-based initiative that seeks to connect insurance provision with investment in NbS to reduce flood and climate-related risks at source. The model is based on the principle that a proportion of insurance-related revenues can be channelled into locally relevant NbS projects, such as wetland restoration, floodplain reconnection, and catchment management, thereby contributing to long-term risk reduction. While such approaches remain at an early stage, they illustrate a potential pathway for aligning risk transfer (insurance) with risk reduction (NbS). Importantly, these models do not replace conventional insurance mechanisms, nor do they eliminate the need for adequate coverage. Instead, they highlight how upstream investment in natural capital could help stabilise insurance availability and affordability over time, particularly in areas exposed to repeat flood losses. For lenders with significant SME exposure, such as Santander, these approaches are relevant not because they directly address under-insurance, but because they point toward integrated frameworks in which insurance, land management, and finance collectively contribute to reducing correlated losses and supporting business continuity.

SMEs represent a particularly high-risk exposure class in flood-prone areas because physical damage rapidly translates into liquidity stress and credit impairment. Under-insurance, limited cash reserves, and operational dependency on specific premises mean that even moderate flood events can trigger loan arrears, business failure, or permanent closure. In

[46] Surminski, S., Eldrige J. (2014). Flood Insurance in England: An Assessment of the Current and Newly Proposed Insurance Scheme in the Context of Rising Flood Risk. Working Paper 144.Available here: https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2014/02/WP144-Flood-insurance-in-England.pdf
[47] Swiss Re Institute (2024). Resilience or rebuild? The costs and benefits of climate adaptation measures for flood. Swiss Re Group, Zurich. Available here: https://www.swissre.com/dam/jcr:8b22bdc2-7330-4952-9c5c-95da8a6094be/swiss-re-institute-expertise-publication-climate-adaptation-resilience-rebuild.pdf
[48] OECD (2026), Financial Protection Against Catastrophic Risks: Floods, Fires and Other Major Risks, OECD Publishing, Paris. Available here: https://doi.org/10.1787/32a3acd7-en
[49] Insure4nature web page. Available here: https://insure4nature.com/

contrast to residential portfolios, where insurance often absorbs initial losses, SME flooding frequently becomes a direct balance-sheet risk for lenders. Reducing flood frequency and severity through catchment-scale NbS therefore has disproportionate value in stabilising SME credit performance and limiting correlated default risk.

Insurance data most relevant to NbS and financial risk

From a financial-sector perspective, not all insurance data is equally valuable for informing NbS investment or lending decisions. The most decision-relevant datasets include:

- **Claims frequency and severity by catchment**, rather than by individual postcode alone, to capture correlated losses and system-level risk.
- **Business interruption claims duration**, which is often more financially material for SMEs than direct property damage.
- **Insurance exclusions and deductibles**, which indicate where residual risk remains even when nominal cover exists.
- **Premium trends and withdrawal signals**, particularly in repeat-loss areas where insurers are reducing exposure.

Integrating these datasets with catchment-scale hydrological models and NbS deployment maps would allow lenders and insurers to better assess whether interventions are genuinely reducing expected losses or merely redistributing risk spatially or temporally.

Investors and financial markets: aligning with ESG, TNFD, and green finance initiatives

For institutional investors and corporate clients, NbS underpin the transition to a nature-positive, climate-resilient economy. The growing adoption of frameworks such as the Taskforce on Nature-related Financial Disclosures (TNFD) and Taskforce on Climate-related Financial Disclosures (TCFD) requires banks to demonstrate how their portfolios account for nature- and climate-related risks.

NbS can unlock innovation in green finance through:

- **Resilience-linked lending:** Loans or mortgages tied to property- or catchment-scale resilience outcomes (e.g., discounts or incentives where NbS reduce exposure).
- **Green bonds and investment products:** Financing NbS projects that deliver measurable carbon, biodiversity, and resilience gains.
- **Reputation and leadership:** As regulators and investors demand demonstrable action on nature, Santander's engagement with NbS can position it as a sector leader in nature-aligned finance.

Examples from peer institutions show tangible opportunities:

- The European Investment Bank's (EIB) Natural Capital Financing Facility has mobilised €100 million into NbS-related projects with robust financial returns.

- UK insurers are beginning to integrate NbS into catastrophe-risk models, recognising the quantifiable reduction in loss potential.

By embedding NbS in portfolio assessments, Santander can reduce exposure to stranded assets while capturing emerging market opportunities in resilience finance.

The wider value of soil health, beyond flood risk reduction

Evidence indicates that soil health interventions deliver substantial co-benefits beyond flood risk reduction. Environmental benefits include carbon sequestration, improved soil structure and infiltration, reduced nutrient and sediment losses, lower erosion, and biodiversity gains (Ashwood et al., 2019[50]; Rameshwaran et al., 2024b[51]). Economic valuations suggest that non-carbon soil services can greatly exceed carbon benefits in monetary terms, supporting a strong societal case for investment (Collins et al.,2022 [52]). Social co-benefits include recreation, aesthetic improvements, stewardship identity, and community engagement, with adoption influenced by cultural context and perceived financial barriers (Bateman, 1996[53] ; Felton et al., 2021[54]; Follett et al., 2024 [55]). Realising these co-benefits at scale requires context-sensitive design, long-term perspectives, and policies that align private incentives with public value (Dittrich et al., 2018[56] ; Hardaker et al., 2021[57]).There are a number of soil health enhancement techniques, including tree planting, agroforestry, cover cropping, reduced tillage, organic amendments and other Nature-Based Solutions (NbS) that deliver

[50] Ashwood, F, Watts, K, Park, K, Fuentes Montemayor, E, Benham, S and Vanguelova, EI. (2019). Woodland restoration on agricultural land: Long-term impacts on soil quality. Restoration Ecology, 27(6), 1381–1392. Available here: https://doi.org/10.1111/rec.13003

[51] Rameshwaran, P, Blake, J, Trill, E, Robotham, J, Bishop, J, Old, G et al. (2024b). Nature-based solutions (NbS) for flood mitigation: Recent UK case studies. E3S Web of Conferences, 599, 02004. Available here: https://doi.org/10.1051/e3sconf/202459902004

[52] Collins, C., Jones, P., and Hannam, J. (2022). Beyond Climate Change Mitigation: The Hidden Economic Co-Benefits of Soil Carbon Sequestration. SSRN Electronic Journal. Available here: https://doi.org/10.2139/ssrn.4282923

[53] Bateman, I. (1996). An economic comparison of forest recreation, timber and carbon fixing values with agriculture in Wales: A geographical information systems approach. Available here: https://repository.nottingham.ac.uk/entities/publication/2f3e184a-6275-4932-aff1-1aeb5d837e37

[54] Felton, M, Jones, P, Tranter, R, Clark, J, Quaife, T and Lukac, M. (2021). Farmers' attitudes towards, and intentions to adopt, agroforestry on farms in lowland South-East and East England. Land Use Policy. Available here: https://doi.org/10.31220/agrirxiv.2021.00110

[55] Follett, E., Davis, L., Wilson, C., and Cable, J. (2024). Working for the environment: Farmer attitudes towards sustainable farming actions in rural Wales, UK. Environment, Development and Sustainability. https://doi.org/10.1007/s10668-024-04459-y

[56] Dittrich, R., Ball, T., Wreford, A., Moran, D., & Spray, C. J. (2018). A cost-benefit analysis of afforestation as a climate change adaptation measure to reduce flood risk. Journal of Flood Risk Management, 12(4). https://doi.org/10.1111/jfr3.12482

[57] Hardaker, A, Pagella, T and Rayment, M. (2021). Ecosystem service and dis-service impacts of increasing tree cover on agricultural land by land-sparing and land-sharing in the Welsh uplands. Available here: https://www.sciencedirect.com/science/article/pii/S2212041621000115

ecosystem services beyond flood risk reduction (Rameshwaran et al., 2024a[58]). Co-benefits tend to span environmental, economic, and social domains (Collins et al.,2022[52]).
Realising these co-benefits at scale requires context-sensitive design long-term perspectives and policies that align private incentives with public value (Dittrich et al., 2018[56] ; Hardaker et al., 2021[57]).

Environmental co-benefits

Carbon sequestration

Soil health interventions such as tree planting on farmland or when degraded land is restored to woodland are commonly understood to have sizeable benefits in terms of carbon sequestration (Crous-Duran et al., 2020[59]; Murphy, Hanley, Ellis, and Lunt, 2020[60]). However, the benefit depends on the soil type and the baseline carbon stock (Housego, Parker, Street, Vanguelova, and Mitchell, 2025[61]). Planting hedgerows can also be beneficial for carbon storage (Biffi, Chapman, Grayson, and Ziv, 2021[62]), as recommended by the Climate Change Committee (CCC, 2019).

Nutrient management and water quality

Improvement to soil health also causes reduced nutrient loss and better water quality. For example, some silvo-arable systems can reduce the loss of nitrogen by 80% compared to conventional arable systems (Garcia de Jalon et al., 2017[63]). UK, water quality monitoring, good NbS practices have shown water quality benefits and pollutant reduction, even where flood mitigation was the primary reason (Ball, 2008[64] ; Rameshwaran et al., 2024b[58]).

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[58] Rameshwaran, P, Blake, J, Trill, E, Robotham, J, Bishop, J, Old, G et al. (2024a). Nature-based solutions (NbS) for flood mitigation: Recent UK case studies. E3S Web of Conferences, 599, 02004. Available here: https://doi.org/10.1051/e3sconf/202459902004

[59] Crous-Duran, J, Graves, AR, Garcia de Jalon, S, Kay, S, Tome, M, Burgess, PJ and Palma, JHN. (2020). Quantifying regulating ecosystem services with increased tree densities on European farmland. Sustainability, 12(16), 6676. Available here: https://doi.org/10.3390/su12166676

[60] Murphy, TR, Hanley, ME, Ellis, JS and Lunt, PH. (2020). Native woodland establishment improves soil hydrological functioning in upland pastoral catchments. Land Degradation & Development, 32(2), 1034–1045. Available here: https://doi.org/10.1002/ldr.3762

[61] Housego, NC, Parker, TC, Street, LE, Vanguelova, EI & Mitchell, RJ. (2025). Natural tree colonisation of organo-mineral soils does not provide a net carbon capture benefit at decadal timescales. Journal of Applied Ecology, 62(3), 617–626. Available here: https://doi.org/10.1111/1365-2664.14861

[62] Biffi, S, Chapman, PJ, Grayson, RP & Ziv, G. (2021). The impact of hedges maturation on soil organic carbon stocks in agricultural landscapes. EGU General Assembly Proceedings. Available here: https://doi.org/10.5194/egusphere-egu21-15091

[63] Garcia de Jalon, S, Graves, A, Palma, JHN, Williams, A, Upson, M & Burgess, PJ. (2017). Modelling and valuing the environmental impacts of arable, forestry and agroforestry systems: A case study. Agroforestry Systems, 92(4), 1059–1073. Available here: https://doi.org/10.1007/s10457-017-0128-z

[64] Ball, T. (2008). Management approaches to floodplain restoration and stakeholder engagement in the UK: a survey. Environmental Management. Available here: https://doi.org/10.2478/V10104-009-0021-0

Reduction of soil erosion

Putting in trees, hedgerows, and riparian buffers that increase perennial cover and improve the soil reduces erosion by stabilising the soil (Stockdale et al., 2018[65]) and also improves downstream water quality (Rameshwaran et al., 2024b[51]). These measures are likely to have a greater impact upstream than on coastal erosion, which is mainly caused by hydraulic pressure from tidal waves, storm surges, and rising sea levels. However, some preliminary studies suggest NbS, such as biochar, may improve underlying soil stability in coastal regions. Whether this is enough to significantly withstand the main factors driving coastal erosion requires future research. The available evidence suggests that different kinds of nature-based solutions specifically focused on reducing coastal erosion – such as seagrass and saltmarsh restoration – are more effective in combatting the main drivers of coastal erosion, which are sea level rise, increasing extreme weather events and associated storm surges. Up to 72% wave energy reduction have been reported for saltmarsh restoration and 80% for seagrass meadows (Justine, Y. E. D., et al. 2025[66]; Wei Chen et al, 2024[67]).

Biodiversity enhancement

Soil health interventions can increase biodiversity by diversifying habitat structure and improving soil biological functioning (Stockdale et al., 2018[65]). Woodland restoration on former agricultural land in England was shown to substantially increase earthworm richness and functional diversity over multi-decade timescales (Ashwood et al., 2019[50]). Regenerative agriculture is designed to enhance soil biological properties, e.g., earthworms, mycorrhizae, and broad, broader biodiversity responses reflecting the expectation of positive biodiversity co-benefits (Berthon et al., 2024[68]). Hedgerows in agroforestry systems are also identified as biodiversity-enhancing elements in intensively managed landscapes, offering habitat and connectivity alongside production (Felton et al., 2021[54]).

Economic benefits

Ecosystem service valuation

Economic valuation studies indicate that soil-based co-benefits can be very large when ecosystem services beyond carbon are included. A UK valuation synthesis reported that for

[65] Stockdale, EA, Griffiths, BS, Hargreaves, PR, Bhogal, A, Crotty, FV & Watson, CA. (2018). Conceptual framework underpinning management of soil health - Supporting site-specific delivery of sustainable agroecosystems. Food and Energy Security, 8(2). Available here: https://doi.org/10.1002/fes3.158

[66] Justine, Y. E. D., et al. (2024). Vegetative nature-based solutions for coastal flood risk mitigation: Effectiveness, challenges and future directions. Science of the Total Environment, 921, 171694. Available here: https://www.sciencedirect.com/science/article/pii/S0964569124005052?via%3Dihub

[67] Chen, W., Staneva, J., Jacob, B., Sánchez-Artús, X. and Wurpts, A. (2024). What-if nature-based storm buffers on mitigating coastal erosion. Science of The Total Environment, 928, 172247. Available here: https://www.sciencedirect.com/science/article/pii/S0048969724023908?via%3Dihub

[68] Berthon, K, Jaworski, CC, Beacham, JD, Jackson, P, Leake, J, McHugh, NM et al. (2024). Measuring the transition to regenerative agriculture in the UK with a co-designed experiment: Design, methods and expected outcomes. Environmental Research: Food Systems, 1(2), 025007. Available here: https://doi.org/10.1088/2976-601x/ad7bbe

every £1 of climate regulation benefit from soil carbon sequestration, an additional £62 of co-benefits may arise from other soil ecosystem services (Collins et al., 2022[52]) .

The estimated total ecosystem service value associated with soil carbon in England and Wales has been reported at £50.8 – 59.7 billion (Collins et al., 2022[52]).

Agricultural productivity and cost savings

Farm level, economic benefits reported by UK farmers from improved soil organic matter management include reduced nitrogen fertiliser requirements, better yields and easier tillage or workability, although these benefits are often perceived as low to moderate in magnitude (Verheijen, 2005[69]). UK surveys of agroforestry perceptions report that farmers associate agroforestry with improved on-farm productivity and additional revenue opportunities, such as timber or fuelwood. But perceived low financial returns are frequently identified as the primary barrier to adoption (Felton et al., 2021[54]). From the available evidence, however, these productivity gains may not be immediate: higher yields may be gradual rather than delayed, and the limited availability of longitudinal studies highlights a significant research gap in understanding the temporal dynamics of sustainable agricultural practice impacts.

Comparative economic analyses and Cost-Benefit findings

Long-horizon modelling in the Welsh uplands suggests that land sharing (agroforestry) can increase ecosystem service benefits, while land sparing (full afforestation) may deliver larger public regulation and maintenance benefits, but at the cost of provisioning losses (Hardaker et al., 2021[70]). UK cost-benefit analysis of afforestation for adaptation similarly indicates positive net benefits dominated by ecosystem services such as climate regulation, aesthetics, recreation and water quality, rather than flood regulation alone (Dittrich et al., 2018[56]). These findings align with evidence that societal benefits exceed private returns, implying a role for policy instruments to bridge incentive gaps (Felton et al., 2021[54]).

[69] Verheijen, F. (2005). PhD Thesis: On-farm benefits from soil organic matter in England and Wales. Available here: https://www.researchgate.net/publication/390666524_On-farm_economic_benefit_from_soil_organic_matter_in_England_and_Wales

[70] Hardaker, A., Pagella, T., & Rayment, M. (2021). Ecosystem service and dis-service impacts of increasing tree cover on agricultural land by land-sparing and land-sharing in the Welsh uplands Ecosystem. Available here: https://www.sciencedirect.com/science/article/pii/S2212041621000115

Social Co-Benefits

Recreation and aesthetic values

Recreation and aesthetic values are often identified as important co-benefits of woodland recreation and related land use change, and they can materially influence the economic case for interventions when monetised (Dittrich et al., 2018[56]). UK evidence indicates that recreation value can be spatially variable and sensitive to planning scale, with national scale planning potentially yielding more combined ecosystem service value than smaller scale approaches (Burke, Rowland, Whyatt, Blackburn, & Abbatt, 2023[71]). Farmer surveys also report perceived improvements in landscape appearance as a social benefit of tree integration and agroforestry (Felton et al., 2021[54]). Soil health interventions that create or enhance accessible spaces (e.g., new woodland, riparian corridors, hedgerows and tree cover) can therefore generate public health co-benefits through increased outdoor recreation and exposure to nature. Annual savings of £108 million have been estimated for the benefits of nature-based recreational activity through preventing non-communicable diseases (Grellier et al., 2024[72]).

Cultural stewardship, identity and community engagement

Cultural identity and stewardship values influence how land managers perceive sustainability interventions. In Wales, studies have shown that farmers emphasise cultural stability, the role of farmers as guardians of the countryside, and community welfare as co-benefits or values linked to sustainable land management choices (Follett et al., 2024[55]). Community stewardship is also evident in urban green commons, where collective management supports awareness of local ecological health and strengthens social links (Dennis, Beesley, Hardman, and James, 2020[73]).

Animal welfare

Agroforestry and tree shelter belts can provide livestock shelter and shade, supporting animal welfare outcomes that are recognised by farmers as meaningful considerations as they affect feed intake, growth rates, milk yield and animal health (Felton et al., 2021[54]). . While welfare impacts are not always quantified, they represent a social or ethical co-benefit with further implications for productivity (Felton et al., 2021[54]). Additional shelter provision can reduce livestock maintenance energy requirements and improve survival rates. These gains are

[71] Burke, T, Rowland, C, Whyatt, JD, Blackburn, GA and Abbatt, J. (2023). Spatially targeting national-scale afforestation for multiple ecosystem services. Applied Geography. Available here: https://doi.org/10.1016/j.apgeog.2023.103064

[72] Grellier, J., White, M. P., de Bell, S., Brousse, O., Elliott, L. R., Fleming, L. E., Heaviside, C., Simpson, C., Taylor, T. & Wheeler, B. W., & Lovell, R. (2024). Valuing the health benefits of nature-based recreational physical activity in England. Environment International, 178, 108667. Available here: https://doi.org/10.1016/j.envint.2024.108667

[73] Dennis, M, Beesley, L, Hardman, M and James, P. (2020). Ecosystem (dis)benefits arising from formal and informal land-use in Manchester (UK): A case study of urban soil characteristics associated with local green space management. Agronomy, 10(4), 552. Available here: https://doi.org/10.3390/agronomy10040552

particularly relevant in exposed landscapes where shelterbelts substantially reduce wind chill (Masters et al, 2023[74]). Mitigating thermal stress through shade and shelter provision can also increase milk yields of dairy enterprises during adverse conditions (England et al., 2019[75]). There are limited credible economic quantifications of the benefits from natural livestock shelter and agroforestry systems. Economic studies tend to be case-specific rather than providing transferrable economic models that stakeholders can reliably use across different contexts and conditions (Jordon et al., 2020[76]).



[74] Masters DG, Blache D, Lockwood AL, Maloney SK, Norman HC, Refshauge G, Hancock SN. (2023) Shelter and shade for grazing sheep: implications for animal welfare and production and for landscape health. Animal Production Science 63, 623–644. Available here: https://doi.org/10.1071/AN22225

[75] England, J. R., O'Grady, A. P., Fleming, A., Marais, Z. & Mendham, D. (2020). Trees on farms to support natural capital: An evidence-based review for grazed dairy systems. Science of the Total Environment, 704, 135345. Available here: https://doi.org/10.1016/j.scitotenv.2019.135345

[76] Jordon, M. W., Willis, K. J., Harvey, W. J. and Petrokofsky, L., & Petrokofsky, G. (2020). Implications of temperate agroforestry on sheep and cattle productivity, environmental impacts and enterprise economics: A systematic evidence map. Forests, 11(12), 1321. Available here: https://doi.org/10.3390/f111121321

The UK Government's Flood and Coastal Erosion Risk Management Research and Development Programme

This extensive and wide-reaching research programme – the FCERM - has been running since 1999. It has included an analysis of insurance preparedness for flooding. When examining the applicability of NFM measures to property owners within specific catchments, it is necessary to ensure that those at high flood risk can actually *access* insurance in the first place. While most residential household owners agree that their insurance premiums are affordable, and most households have both buildings and contents insurance, significant gaps remain. A much lower proportion of households in the rental sector have contents insurance. Only 13% of all SMEs had building insurance, with business property insurance held by around half. 23% of all SMEs hold business interruption insurance. Less than half with business property or business interruption cover reported that it included flood cover[77].

The FCERM programme includes reviews of 65 case studies of flood risk management projects that 'Worked With Natural Processes' (WWNP), in a 2018 report that was updated in 2024[78]. Within WWNP are a series of 17 different measures to address flood and coastal erosion, including measures from within river and floodplain management, woodland management, and coastal and estuary management, but we can focus here on a fourth category, run-off management, and specifically the sorts of measures that UK farmers and land managers can put in place to manage upstream factors of flood risk.

Subsoiling

Subsoiling is deep tillage, usually 12+ inches deep. There is some observed evidence on flood flows, peaks and storage. In Brookings, South Dakota, Chalise et al (2019)[79] showed that returning crop residue to silty, loamy soils resulted in 7% lower bulk density, 22% higher soil organic carbon (SOC) and 66% higher infiltration than non-treated areas. These improvements in soil structure and function increased over time during the 16-year study period.

Modelled evidence is also positive, for example the flood peak in the Brimfield Brook in north Herefordshire (30 km2) could be reduced by a maximum of 11% (1 in 2-year return period (RP))

[77] DEFRA (2023). Review of affordability and availability of flood insurance to help evaluate the effectiveness of flood-resilience measures (Phase 1). Flood and Coastal Erosion Risk Management (FCERM) Research Programme, Environment Agency, Bristol, UK. Available here: https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/review-of-affordability-and-availability-of-flood-insurance-to-help-evaluate-the-effectiveness-of-floodre

[78] Pearson, E., Baldwin, M., Bard, H., Bromley, T., Broomby, J., Burgess, L., Champion, H., Evans, H., Hankin, B., Hastewell, L., Hemsworth, M., Humphries, A., Langler, G., Maslen, S., Prtak, E., Rees, C. & Rose, S. (2025). Working with natural processes: Evidence directory update - Research Report FRS21232/RR2. Flood and Coastal Erosion Risk Management (FCERM) Research and Development Programme, Environment Agency, Bristol, UK. Available here:https://assets.publishing.service.gov.uk/media/67c6e14c68a61757838d2265/FRS21232_Research_report.pdf

[79] Chalise, K, Singh, S, Wegner, B, Kumar, S, Pérez-Gutiérrez, J, Osborne, S, Nleya, T, Guzman, J & Rohila, J. (2019). Cover crops and returning residue impact on soil organic carbon, bulk density, penetration resistance, water retention, infiltration, and soybean yield. Agronomy Journal, 111(1), 99–108. Available here: https://acsess.onlinelibrary.wiley.com/doi/abs/10.2134/agronj2018.03.0213

to 17% (1 in 100-year RP) if all of the catchment had land management measures implemented on it, including arable subsoiling, reducing stocking densities and measures that reduce soil compaction. The modelling suggests that this could be reduced further to 26% during a 1 in 100-year event if all catchments had land-use NFM measures, including arable reversion. Currently, NFM implemented on 3% of the catchment has reduced the flood peak here by 1% (Lewis and Hodges, 2021[80]).

Regenerative agriculture (minimising/avoiding tillage, eliminating bare soil and encouraging plant diversity) practices in 2 fields on a farm in Hertfordshire (Thames catchment, at the Stort upstream from Roydon), with the same soil, geology and climate were compared. Modelling showed that soils in the regenerative agriculture field responded more dynamically and had greater infiltration and drainage rates in these, in comparison to the adjacent control field where there was significantly less drainage and more waterlogged soils. The regenerative agriculture field (2.57 ha) stored up to 2,000 m3 more water than the waterlogged control field (Mulligan et al, 2023[81]).

Soil aeration

In terms of observable evidence, in Penrith, Cumbria, aeration increased hydraulic conductivity by up to a factor of 7.5 in stagnosols (soils characterised by stagnating surface water). Aeration decreased the occurrence of infiltration excess overland flow, reducing likelihood from 11.4% of all rainfall event periods during the study period pre-aeration, to 0.09% post-aeration, although this was dependent on natural soil variation (Wallace and Chappell, 2019[82]). In addition, a study of 164 fields with 5 soil types and 4 land uses on the West Thames catchment was carried out by (Blake et al.,2022[83]). They found that if the organic matter content of soils is between 1 and 4%, modest increases in organic matter can significantly increase porosity. 2% organic matter in soils gave an average of 38% near-surface estimated porosity, while 5% organic matter gave a 51% porosity when an average was taken across all fields.

Stocking density

A study in Swindale, Cumbria used a hillslope flume to investigate overland flow velocities in 4 headwater grassland habitats: low density grazing, hay meadow, rank grassland and rush

[80] Lewis and Hodges. (2021). River Wye and Lugg Natural Flood Management Project: Dulas Brook catchment. Available here: https://bredenburygroup-pc.gov.uk/wp-content/uploads/2019/11/FLOOD-MANAGEMENT-LEAFLET-FINAL-HFD3496.pdf

[81] Mulligan, M, van Soesbergen, A, Douglas, C & Burke, S. (2023). Natural Flood Management in the Thames Basin: Building Evidence for What Will and Will Not Work. In: López-Gunn, E., van der Keur, P., Van Cauwenbergh, N., Le Coent, P. & Giordano, R. (eds) Greening Water Risks: Water Security in a New World. Springer, Cham. Available here: https://doi.org/10.1007/978-3-031-25308-9_12

[82] Wallace, E and Chappell, N. (2020). A statistical comparison of spatio-temporal surface moisture patterns beneath a semi-natural grassland and permanent pasture: From drought to saturation. Hydrological Processes, 34(13), 3000–3020. Available here: https://research.lancaster-university.uk/en/publications/a-statistical-comparison-of-spatio-temporal-surface-moisture-patt/

[83] Blake, J, Trill, E, O'Brien, A, Robotham, J, Scarlett, P, Old, G & Rameshwaran, P. (2022). LANDWISE field surveys: How land use and soil management affects soil properties, with implications for flood risk. [Speech] In: NERC Natural Flood Management Programme Finale Event, Online, 7 July 2022. (Unpublished). Available here: https://nora.nerc.ac.uk/id/eprint/533717/

pasture. Overland flow visibly occurred for longer when habitat is ungrazed. This may be a consequence of enhanced storage in more highly vegetated ungrazed habitats, through which surface water cannot flow downslope as readily and, therefore, the time for which overland flow lasts is longer(Bond et al, 2020[84]).

Evidence is supported by models, too. A study in Coverdale suggested that grazing on Higher Level Stewardship (HLS) land results in more than twice the relative change to the baseline ungrazed condition scenario (considered to be a 'normal' land management scenario with a uniform Eriophorum surface cover and no soil compaction in this case) compared to grazing on Entry Level Stewardship (ELS) land. The modelled scenario with both ELS and HLS areas grazed has a large impact on river flow peaks with, for example, even just for the light grazing scenario, a predicted 18-minute earlier flow peak and a 32.9% increase in peak discharge for the 15 mm storm event. Heavy grazing scenarios had much greater influence on flow peaks than light grazing; for the same 15 mm storm with grazing across the ELS and HLS areas the peak was 42 minutes earlier and 82.2 % higher than baseline (Gao et al 2017[85]).

Improving vegetation cover in grassland systems

In Devon, land management that prioritises limiting soil degradation showed that unimproved grassland reduced the run-off coefficient (a dimensionless coefficient relating the amount of run-off to the amount of precipitation received) and increased water storage within microtopographic depressions due to more diverse vegetation. Water storage was around 3 times higher in a 30% unimproved grassland scenario compared to a 10% unimproved grassland scenario (Ellis, 2021[86]).

Arable systems – conservation tillage

Razmand et al (2019)[87] modelled the effects of the adoption of no-till farming and cover crops in the Clear Creek Watershed (270 km2), Iowa, using a GHOST model. Cover crops/no-till practices reduce peak discharges for all the years, and for the largest floods (exceedance probability < 20%), simulation results also show reduced peak discharges. The model was calibrated and validated using a 15-year continuous simulation with hourly climatological data. Simulated hydrographs were compared against measurements taken at 2 USGS flow gauging stations.

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[84] Bond, S, Kirkby, M, Johnston, J, Crowle, A and Holden, J. (2020). Seasonal vegetation and management influence overland flow velocity and roughness in upland grasslands. Hydrological Processes, 34(18), 3777–3791. Available here: https://onlinelibrary.wiley.com/doi/full/10.1002/hyp.13842

[85] Gao, J, Holden, J and Kirkby, M. (2017). Modelling impacts of agricultural practice on flood peaks in upland catchments: An application of the distributed TOPMODEL. Hydrological Processes, 31(23), 4206–4216. Available here: https://eprints.whiterose.ac.uk/id/eprint/121726/1/Gao_et_al-2017-Hydrological_Processes.pdf

[86] Ellis, N. (2021). Understanding the capacity of unimproved grassland to deliver natural flood management. PhD thesis. Available here: https://ore.exeter.ac.uk/articles/thesis/Understanding_the_capacity_of_unimproved_grassland_to_deliver_natural_flood_management/29785325#:~:text=The%20research%20presented%20in%20this,agriculture%2C%20could%20provide%20NFM%20benefits.

[87] Razmand, M, Politano, M, Amado, A and Weber, L. (2019). A physically-based coupled hydrologic model for Clear Creek Watershed. IAHR Online Proceedings. Available here: https://doi.org/10.3850/38WC092019-1459

Arable systems – early sowing winter crops and cover crops

Compared with arable soils, grass-clover leys in Yorkshire demonstrated several beneficial effects at a study site near Leeds on loamy, calcareous brown earth. These included an increase in earthworm populations, greater macropore flow, improved saturated hydraulic conductivity and a reduction in bulk density. Infiltration rates in arable soils were around 260 mm h-1, 75 mm h-1 in leys and 740 mm h-1 in grass-clover leys. Grass-clover leys contribute to the rejuvenation of earthworm communities and the reversal of structural deterioration in intensively cultivated arable soil. This facilitates the adoption of no-tillage farming practices, breaking the cycle of soil degradation driven by repeated ploughing (Berdeni et al, 2021[88]).

Swales and scrapes

NFM interventions on the Weybourne/Spring Beck (3.5 km²) in north Norfolk included the creation of 3 scrapes and a swale, along with the planting of 400 trees, creation of 11 leaky barriers and 3 large woody debris screens. The scrapes alone stored 2,400 m³ of water. The suite of measures created led to a reduction in peak discharge of 7% for a 50% Annual Exceedance Probability (AEP) event (George and Todd, no date[89]).

These soil management interventions, according to the FCERM programme, compare with other NbS commonly deployed to manage flood risk. River restoration (re-meandering, reintroduction of braided channels), floodplain restoration (fens, reedbeds, peat bogs and wet woodland), leaky barriers (log jams etc), the re-introduction of European beavers (*Castor fiber*), the creation of offline water storage areas, and the creation of floodplain and riparian woodlands are held with medium confidence to have a positive effect on flood risk. Likewise, soil aeration, subsoiling, reduced stocking density, improved vegetation cover, cover crops, and regenerative agriculture are also understood to potentially increase surface storage, surface roughness, infiltration rate, and the soil's capacity to store water. However, the extent to which these measures reduce flood risk depends on the initial soil wetness, location, and the area of land managed relative to the size of the catchment. Nonetheless, and despite the broad and complex set of soil-focused measures, the conclusion again is 'medium confidence' that these activities can have a positive effect on flood risk. The research gaps identified in this report are being addressed currently via an ongoing NERC research call on NFM. These are summarised below:

[88] Berdeni, D, Turner, A, Grayson, R, Llanos, J, Holden, J, Firbank, L, Lappage, M, Hunt, SPF, Chapman, PJ, Hodson, ME, Helgason, T, Watt, P & Leake, J. (2021). Soil quality regeneration by grass-clover leys in arable rotations compared to permanent grassland: effects on wheat yield and resilience to drought and flooding. Soil and Tillage Research, 212, 105037. Available here: https://doi.org/10.1016/j.still.2021.105037

[89] George and Todd. (n.d.). Small-scale NFM interventions in Essex, Norfolk and Suffolk: Weybourne / Spring Beck, Norfolk. Available here: https://www.therrc.co.uk/assets/files/Conference/2019/Presentations/2.1.1._george_helen.pdf

Research and evidence gaps:

1 **The flood risk impact of WWNP measures across different scales, on:**

- flood level/flow;
- flood peak;
- flood storage.

What scale/extent for a WWNP measure is needed in a catchment to reduce flood risk? How effective are measures when soils are fully saturated?

2 **Performance and design life**: the whole life performance and engineering design standard of WWNP measures need to be understood, especially:

- whole life costs of measures
- standard of protection to downstream communities
- comparative assessments between WWNP/NFM and traditional measures • how long it takes for the measures to work
- how long the measures last (design life)
- how frequently they need to be maintained

3 **Typology, geology, sediment management and conveyance**; how do WWNP measures function in different catchment typologies/geologies and what effect do they have on sediment management and conveyance?

A further element of the FCERM examined methodologies to estimate the economic benefits of NFM projects. At the moment, many of these interventions are low-cost, led often by communities. They face challenges in securing funding. Research led by the Environment Agency identified the need to develop resource-intensive hydrological modelling and/or monitoring as critical. As a result, there is now a consistent, practical and scalable way of estimating flood risks and environmental co-benefits across these and other interventions. The input values of soil management for air pollutant removal, carbon sequestration and biodiversity can all be standardised[90].

Missing evidence

Despite the strong evidence from NEIRF and FCERM, an analysis of databases of NbS in general – from around the UK and elsewhere in the world – finds a worrying lack of published reports that monitor impact. Of 1,781 case studies, only 660 (37%) - confirmed that a formal monitoring system was in place. To reach a point where such interventions are truly investable will require a reduction in the transaction costs associated with monitoring and verification.

[90] Environment Agency / UK Government (2024). Evaluating the effectiveness of nature-based flood management measures: Research Report FRS23248/RR2. FCERM Research and Development Programme, Environment Agency, Bristol, UK. Available here:https://assets.publishing.service.gov.uk/media/689c5abc87bf475940723edb/FRS23248_Research_report.pdf

Natural Environment Investment Readiness Fund

The Natural Environment Investment Readiness Fund (NEIRF) is a government-funded grant programme that aims to increase the number of financing options for natural environment projects by stimulating a pipeline of scalable and replicable projects that protect and enhance the natural environment. The NEIRF aims to generate revenue and repay the investment.

Of 86 projects funded through NEIRF, five aimed to generate revenue through NFM. As such, it is an important focus of the Fund, but not a primary one, with flood management usually aligned with biodiversity, carbon, or nutrient management revenue streams. The NEIRF programme has highlighted concerns around the measurement and monitoring of ecosystem services gains via NbS. There is no standard approach to monitoring. For example, for habitat and species recovery, projects had to select which metrics were most appropriate and cost-effective to measure on a regular basis, selecting indicator species for biodiversity units. Projects were also concerned about whether their selected methodologies would still be seen as credible and appropriate in a few years' time.

At root, the question of Monitoring, Reporting and Validating (MRV) data from NbS interventions continues to act as a brake on investment, as without project-specific, high-quality data, and access to existing data in order to set baselines, meaningful Key Performance Indicators (KPIs) and investable business cases cannot be confidently established. Information on exact changes – surface water runoff volumes, tonnes of pollutants removed, etc. – needs to be developed to allow for more accurate and detailed value-for-money assessments.

Overall, the external evaluation of NEIRF for NFM outcomes concluded that significant lead-in time was required to secure success. Awareness-raising of benefits and revenues associated with NFM measures with farmers and other land managers takes time, and resistance or suspicion needs to be overcome. The knowledge of existing codes, for example, the woodland carbon code, is crucial[91].

[91] Ecorys / Natural Environment Investment Readiness Fund (NEIRF) (2024). Evaluation of the Natural Environment Investment Readiness Fund (NEIRF): Final report (Rounds 1 & 2). Available here: https://www.greenfinanceinstitute.com/wp-content/uploads/2025/12/Ecorys-NEIRF-evaluation.pdf

Case studies

In this section, we present the findings of a survey of different NbS databases[92] [93] [94], that taken together demonstrate a broad and growing interest in NbS as a vehicle for risk reduction or for securing investment opportunities (or very often, both). The table below summarises the key features, implementation costs, and outcomes across these databases, including damages avoided (where this has been effectively monitored). For further reading, a full comparison of case studies is provided in Appendix 1 and 2.

Table 1: Comparative view of catchment-level NbS programmes.

Catchment Scale	Typical Size	Example Projects (UK only)	Typical NbS Measures	Implementation Cost (Range)	Avoided Damages (Evidence)	Properties / Assets Protected	Key Outcomes	Key Funding Sources
Small catchment	~10 km²	Mill Brook (16 km², Cheshire), Padgate Brook (5 km², Warrington), Low Stanger (North Yorkshire), Mayes Brook (London, park-scale)	Leaky dams, woody debris, small bunds, SuDS, wetlands, riparian planting	£4k- £250k (most £10k - £100k)	Rarely quantified, ecosystem service valuation is available in some cases	~20–200 properties	Rapid runoff reduction; local flood storage; high cost–benefit ratios	Local authorities, Environment Agency (FCRM), RFCC Local Levy, NGOs, partnerships
Medium catchment	~100 km²	Eddleston Water (69–75 km², Scotland), Pickering "Slowing the Flow" (69–92 km², England), River Frome (109 km², Dorset), River Otter Beaver Trial (~250 km², Devon)	Woodland planting, river re-meandering, floodplain reconnection, storage ponds, bunds, beaver dams, catchment land management	£0.8M - £4M (typical £1M - £3.5M)	For some, quantified avoided damages Eddleston; multi-million estimates for Pickering)	~100–500+ properties	Peak flow reduction (~10–30%); delayed flood peaks; catchment-scale hydrological change; strong biodiversity, water quality and carbon co-benefits	Defra, Scottish Government, Environment Agency, research programmes, partnerships (e.g. Forestry Commission, NGOs)
Large catchment	~1,000 km²	River Avon (1,750 km², Hampshire/Wiltshire), River Chelmer (~988 km², Essex), New Forest LIFE III (multiple headwater systems within larger catchments), Garron Plateau peatland (NI, system-scale)	Floodplain restoration, wetland creation, peatland restoration, river restoration, managed realignment, and large-scale land management	£2.9M – £4M+ (project-scale; full system costs higher)	Rarely directly monetised	Communities / regional scale (hundreds to thousands indirectly – not expressed)	System-wide flood regulation; increased floodplain storage; resilience to extreme events; major carbon storage, water quality and biodiversity benefits	UK Government, Environment Agency, Northern Ireland agencies, and large multi-partner programmes

[92] Urban Nature Atlas (no date) Urban Nature Atlas.
Case studies listed within the Flood and Coastal Erosion Risk Management Research and Development Programme (Working with natural processes to reduce flood risk 2024 - GOV.UK).
[93] Nature-based Solutions Initiative (NbSI) (no date) Nature-based Solutions Initiative database.
[94] The NEIRF case study database.

Visualising Nature-based Solutions

The graphics on this page help to visualise the catchment-scale process for managing flood risk through NbS (Figure 2) and the typical inputs and benefits for a catchment-scale project (Figure 3). Figure 3 is an indicative example, based on key impacts, NbS measures, benefits and costs from Pickering Beck, Eddleston Water and Mayes Brook case studies. Pickering and Eddleston were selected for their similar catchment size (~70km^2), with the smaller Mayes Brook catchment incorporated to show impact in an urban area.

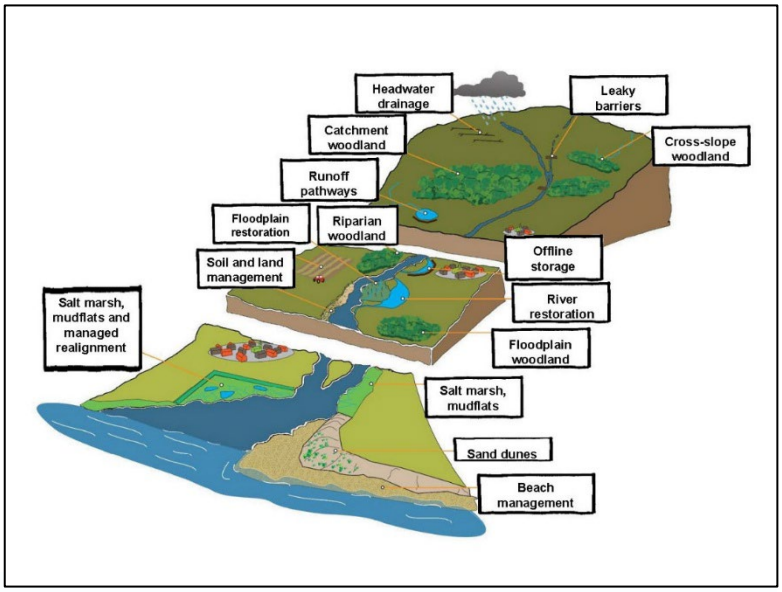


Figure 2 (right): Catchment-scale natural flood-management measures

Figure 3 (below): Illustrative visual case study, based on a medium catchment.

INVESTMENT COST

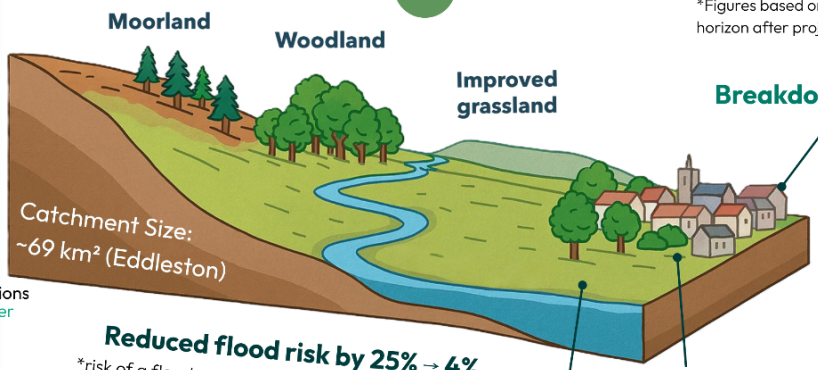
£750k → £4 million

Funders:
National Government

Implementation Partners:
Forestry England
Land management
Environment Agency
Risk and modelling
National Park Authority
Landscape planning
Local councils
Delivery & community
Research institution
Evidence and impact
Environmental organisations
Delivery and stakeholder

Breakdown of Costs:





Reduced flood risk by 25% → 4%
*risk of a flood event occurring in any given year
15-20% reduced runoff and 40-50 properties protected during flood event in 2015 (Pickering Beck)

DAMAGE without intervention

Pickering Town was flooded **four times in 15 years** prior to project completion, an estimated £7 million. Since 2015, there have been no reported flood events.

Environmental benefits

- Carbon storage
- Improved water quality
- Biodiversity and habitat provision
- Improved agriculture yields

POSITIVE IMPACT

Benefit-cost ratio:
1.5 → 7.1

Net positive value:
£1.9 million → £26 million

*Figures based on 100-year time horizon after project completion

Breakdown of Benefits:

Homes Protected From Flood Damage

Reported values range from £55,000 per/year to £950,000 over lifecycle (Eddleston), but are more often, not reported at all.

Note: Average property value makes a significant difference to cost-benefit ratios. This is most clearly shown in the densely populated urban catchment of Mayes Brook, where £750k implementation cost brought £26m in ecosystem benefits.

Socioeconomic Benefits:

- Mental health and economic benefits for residents
- Local economic growth and protectied industries
- Community cohesion and access to nature

Case study 1 – Hill Stone Wood NEIRF project

United Kingdom

Hill Stone Wood (HSW) is a green financial services company aiming to create a new home insurance brokerage service to reinvest 80% of profits into NbS. HSW will be presented to homeowners via distribution partners such as nature-based charities and water companies as a '**green insurance brokerage'** that puts its profits into services that improve nature-related challenges. Revenues from HSW home insurance will pay for environmental benefits initially in NbS projects closest to policyholders' landscape catchment area. As the model expands, the proximity of funded NbS projects to policyholders' homes will increase. HSW operates on different catchments: Ancholme; Dorset Stour; Ouse and Adur; and the Wyre.

Environmental outcomes

Contributions to NFM activities, including promoting swales and permeable surfaces to capture, filter and store water surface run off. Improvements to wetland biodiversity.

Socioeconomic outcomes

Reduction of the risk to specific buildings and properties. The risk is aggregated and redistributed across a catchment area.

Finance

The aim of the project is to secure, over time, the monthly release of funds from home insurance payments that will provide a secure and stable revenue stream to catchment partnership initiatives that fit 25-50 year goals. The long-term sustainability of the funding is based on high business retention levels (75%+) in the insurance industry.

Monitoring and evaluation

A key innovation for Hill Stone Wood is to use revenue from selling home insurance to customers for NbS, and to ensure funds go to the nearest catchment-based project to the postcode of the home purchasing the insurance. It allows homeowners to fund NbS within their area, enhancing their local amenities and providing valued ecosystem services. The project seeks to change consumers' relationships with home insurance, through showcasing the value of their investment into NbS. Project evaluation highlighted the need for a collective effort to fill the gaps that exist between buyers, sellers, investors, policymakers and data, and to build the role of intermediaries in natural capital markets. It also demonstrated that a focus on credit markets to ecosystem service delivery, to the exclusion of other revenue models including insurance, is a mistake.

Case study 2 – Eddleston River restoration for natural flood management

United Kingdom

Eddleston Water was a straightened river that risked flooding 500 properties downstream. Therefore, the Scottish Tweed Forum embarked on an assessment of the natural flood management potential associated with restoring Eddleston Water. Working with local landowners, they managed to plant over 200 hectares of native trees, create cross-slope hedgerows, and install 116 log barriers on high tributaries to create small wetlands. Furthermore, 28 flood storage ponds were created, three kilometres of the main river were re-meandered, and several embankments were removed reconnecting the river with its surrounding floodplain.

Environmental outcomes:

Analysis reported that flood peaks were reduced by 30% and delayed by over four hours, avoiding an estimated £950,000 of flood damages and protecting 500 properties downstream.

Gravel banks and pools formed by the restoration of the river have improved habitat quality which has led to an increase in spawning salmon and other fish. Ecological status of the river has been improved from 'bad' to 'moderate' under the EU Water Framework Directive Assessment.

Socioeconomic outcomes:

The project has worked with landowners, farmers and foresters to ensure continued profitability for local industries while also supplying reduced flood risks and potential for economic damages to surrounding areas.

Governance

Broad partnership (The Tweed Forum) including government bodies, NGOs, local landowners, and regional communities.

Finance

The project is financed by the Scottish Government and the Scottish Environment Protection Agency (SEPA).

Monitoring and evaluation

A highly comprehensive monitoring program has been implemented with hydrometric network monitoring, groundwater monitoring, water quality measurements as well as ecological and geomorphological surveys.

Nature-based Solutions: little evidence of private sector taking the lead

As we have noted, the private sector is not investing in these interventions as much as is required to fill the UK's nature restoration funding gap. Our research has found that just 15% of NbS projects are led by the private sector, and only 0.3% are led by financial institutions. Others were utility companies, major infrastructure corporates such as Network Rail and Crossrail, extractive industries such as gravel extractors (who put up most of the € 550m that financed the Meuse river restoration and floodplain creation in the Netherlands, a "unique financing mechanism" that ensured it was "the only large-scale river restoration not cancelled during the 2008 financial crisis"[95]), financed through carbon credits[96], or delivered by a specialist full-spectrum NbS company, for example, Toroto in Mexico. The financial sector institutions that are leading the way tend to be infrastructure and development banks, and insurance providers.

Addressing flood management objectives within riparian ecosystems. Within the databases of NbS projects that we surveyed, a focus on riparian ecosystems was a feature of just over 22% of them. A focus on rivers and streams is often a feature of urban-based examples.

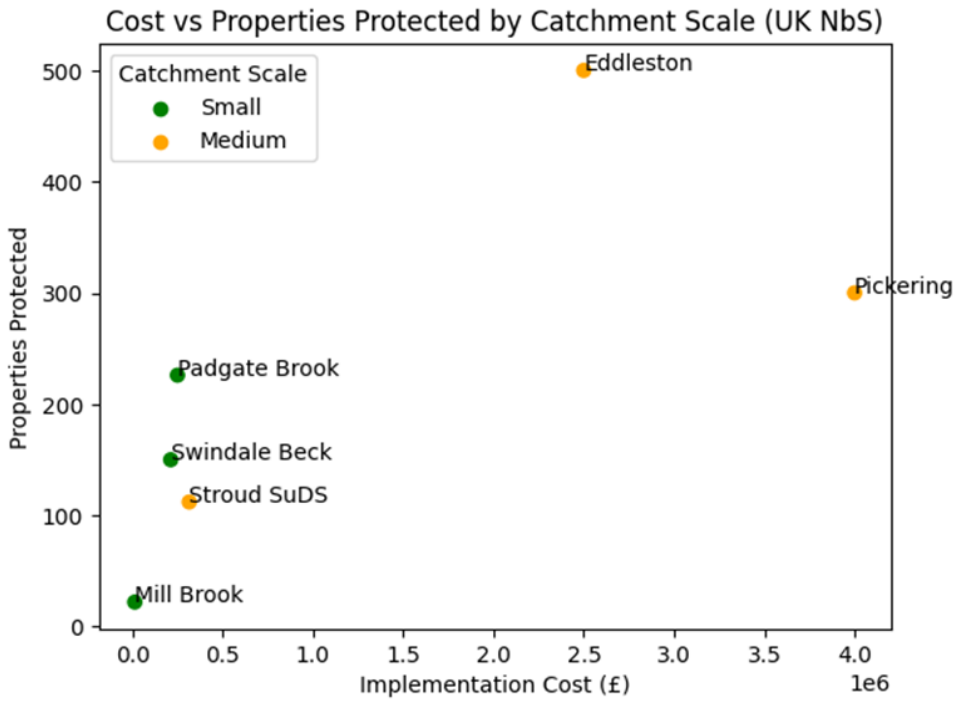


Figure 4: Catchment-scale case studies compared by cost to properties protected

[95] Nature-Based Solutions Initiative (NbS Initiative) (2025). NbS case studies database. Nature-Based Solutions Initiative. Available here:https://casestudies.naturebasedsolutionsinitiative.org/case-search/
[96] Green Finance Institute. (2023). Trees for Life: Case Study. Available here: https://www.greenfinanceinstitute.com/hive/revenues-for-nature/case-studies/trees-for-life/

Case study 3 - Million Streams Project

New Zealand

The Million Metres Streams project is run by the Sustainable Business Network and focuses on brokering financing for community-led waterway restoration projects. The project aims to raise $10 million over the next 5 years for these projects and secures financing through partnerships with philanthropic organizations and the private sector. Until 2022, the project had accepted crowdfunding as a financing mechanism, but has updated its protocols to focus solely on businesses and philanthropic organisations.

The waterways of New Zealand currently exist in a highly degraded state. It is reported that 82% of river length in pastoral farming areas and 94% of river length in urban areas are not suitable for swimming due to pollution. On top of this 90% of the countries historic wetlands have been destroyed for alternative uses and 76% of native freshwater fish species are threatened.

Mitigation: The project reports that large scale native species revegetation efforts will lead to carbon sequestration, however it does not provide projections or measurements for what the total amounts would be.

Adaptation: Plantings of native species along the waterways has reportedly improved water quality and helped limit erosion. The restoration of native wetlands has also reportedly helped with water management and flood mitigation through holding large volumes of water within the landscape.

Ecological effect: The project has helped improve habitat extent and quality for both terrestrial and freshwater species.

Socioeconomic outcomes: the project reportedly places a large emphasis on community involvement in nature restoration. Some of its projects host community restoration days and host school groups at project sites. Projects will also have employees from the corporate funders of the Million Metres Streams project out for volunteer days to see what their financial contributions help support.

Governance: managed by the Sustainable Business Network and governs the allocation of funding across the country. The individual or community organization which is the funding recipient then governs the implementation of the restoration on their land.

Finance: under charitable and crowd-funding models the project was able to raise $2.3 million. As the program has grown they recently made the pivot in 2022 to focusing on business and philanthropic support exclusively in order to reach their goal of raising $10 million for waterway conservation in the next five years.

Case Study 4 – Wallasea Island Wild Coast restoration project

United Kingdom

Recreating a wetland landscape of mudflats, saltmarsh, lagoons and pasture in an internationally important estuary using a managed realignment strategy. Europe's largest coastal habitat restoration project is a partnership between RSPB and London Crossrail, reusing 3 million tonnes of clean spoil excavated from project tunnelling to raise land above sea level and breaches in the existing sea walls, creating 115 hectares of new tidal wildlife habitat. The project is expected to future-proof coastal areas against sea-level rise, store carbon, and increase habitat for overwintering waders and wildfowl.

Climate change mitigation: It is reported that the Wallasea Island Nature Reserve site, home to the Wallasea Island Wild Coast Project, sequesters two tonnes of carbon per hectare per year.

Climate change adaptation: The newly created intertidal areas have been designed so that the salt marsh will rise as sea levels rise and reduce flood risk across the estuary system.

Ecological effect: The Wallasea Island site has been designated as a Ramsar site and Special Protection Area as a breeding site for migratory birds

Socioeconomic outcomes: the scheme is designed to improve the defensive protection of buildings located on the west of the island by the construction of a new counterwall, which will also reduce long-term seawall maintenance costs (estimated as between £650,000 and £5-10 million over the 10 years from 2010).

Governance: partnership between Crossrail, DEFRA, RSPB, Natural England and Wallasea Farms.

Finance: Grant funding was provided by Viridor Credits, Enovert Community Trust (£70,000) and Banister Charitable Trust. The EA also provided significant funding, which secured 155 hectares of saltmarsh and mudflat on Wallasea Island. Crossrail financed the transport of excavated soil materials by barge and the unloading facility on Wallasea Island.

Monitoring and evaluation: The project has three main monitoring activities: (1) impact verification monitoring (pre and post-breaching); (2) sediment settling and ecological functioning monitoring (ongoing and post-breach); and (3) mitigation habitat success monitoring (post-implementation).

Case Study 5 – River restoration and hillside stabilization near Swindale Beck

United Kingdom

Restoring a historically straightened stream to its natural meandering path to slow the flow of water through the valley, reducing downstream flood risks and improving water quality, habitat creation, and biodiversity. This project involved restoring 1,140 metres of heavily human-modified river, 1,000 hectares of bog and 15 hectares of species-rich hay meadow within the Swindale Beck catchment.

Climate change mitigation: Not reported, though it is asserted that the wider project will lead to improved soil carbon storage from changed grazing practices and peat bog restoration.

Climate change adaptation: The project reports that it will contribute to reducing flooding risk in Cumbria triggered by natural disasters, such as 2015's Storm Desmond, which caused significant local damage.

Ecological effect: It is reported that a few months after work was completed, salmon were able to spawn on these banks, for the first time in centuries. The increased habitat diversity now supports a much wider range of invertebrates. The restored natural gravel beds proved suitable spawning grounds for Atlantic salmon (*Salmo salar*) and otters (*Lutra lutra*) have been reported as being seen hunting along the river's new course.

Socioeconomic outcomes: The project will reportedly provide flood risk reduction benefits to 150 properties at risk of flooding at Eamont Bridge, a village downstream of the Swindale Beck catchment. The project has reportedly contributed to improved raw water quality into the Haweswater Reservoir, which the Swindale Beck feeds into, by reducing soil erosion and run-off and improving the land's ability to store water.

Governance: In 2012, the Royal Society for the Protection of Birds (RSPB) leased Swindale Farm and nearby Naddle Farm from United Utilities for a period of 45 years. The Swindale Beck restoration project was jointly led by RSPB and United Utilities, who partnered because of a shared interest in improving catchment.

Finance: The total cost of the project was £212,500. Funding was provided by the EA (£70,000), Natural England (£52,000), United Utilities (£40,000), RSPB (£25,000), and Cumbria Waste Management Environment Trust (£25,000).

Monitoring and evaluation: Water quality and water flow is monitored by United Utilities. It is reported that modelling to assess the feasibility and contribution that new flood attenuation structures could make to downstream flows after extreme rainfall events is also being undertaken.

Case Study 6 – Meuse River restoration and floodplain creation

Netherlands / Belgium border

Conservation organizations, gravel extraction companies, and the local government teamed up to create a 45km stretch of rewilded river with increased flood prevention capacity and biological regeneration. The role of the private sector, in the form of dredging companies which wished to harvest gravel from the Meuse river, was critical. The project also included placing 200 ha of riverside lands under naturalistic grazing regimes to help facilitate regeneration. Beaver (*Castor fiber*) and otter (*Lutra lutra*) were also reintroduced to the landscape.

Climate change mitigation: Not reported

Climate change adaptation: The widened river with the inclusion of floodplains and natural flow patterns has reportedly increased the areas resilience to flooding. The system is designed for one-in-250 year flooding occurrences. There was a test of the system in July 2021 when large scale flooding occurred in the basin, but all houses around the restored river area remained dry and undamaged.

Ecological effect: The project contributed to improving habitat quality along the river and ecological monitoring studies of the intervention have reported highly successful recolonization of riverine flora and fauna.

Socioeconomic outcomes: The project has become a key draw for tourists with two million visitors coming annually generating approximately €1bn of revenue for the Meuse region.

Governance: Current Dutch governance of the project is managed under the Consortium Grensmaas, which is made up by members from the gravel extraction sector, civil engineers and the private conservation organization Natuurmonumenten.

Finance: The total financing for this project is €550m, with the project financed mainly by companies who are extracting sand and gravel from the existing riverbed.

Monitoring and evaluation: Ecological monitoring has been conducted on the river to evaluate recolonization of flora and fauna. Monitoring also takes place to track introduced species such as otters and beavers within the system.

Case Study 7 – Beaver re-introduction on the River Otter in Devon

United Kingdom

Through community-based trial and error, the UK's first beaver (*Castor fiber*) reintroduction attempt aimed to restore healthier functioning of the River Otter ecosystem and reduce downstream flooding impacts on local communities. Over the course of four years, the two original beaver families had built 28 dams on various tributaries in the river catchment and impounded almost two kilometres of the river creating reservoirs that serve critical ecological functions and likely aid biodiversity recovery.

Climate change mitigation: Not reported

Climate change adaptation: The dams created by the beavers have been reported to reduce the flood risk to downstream villages and improve water quality by trapping sediment often washed into tributaries. These improvements are likely to strengthen the adaptive capacity of local communities and wildlife to climate change impacts.

Ecological effect: The diverse and constantly changing constellation of ponds and wetlands is reported to have increased the presence of water voles, amphibians, trout, and lamprey. The dams and ditches created by the beavers have also been shown filter silt and chemicals improving water quality.

Socioeconomic outcomes: Although the dams have reduced flood risk to a downstream village, surrounding communities complained that beaver dams occasionally created localised flooding of farmland. The project implementers have worked to resolve these conflicts and community members volunteer to reduce these impacts.

Governance: The initial beaver release was approved by Natural England and managed by the Devon Wildlife Trust. The project came to inception through the support of the local community and received further logistical support form the university of Exeter and the RSPB.

Finance: Devon Wildlife trust provided the funding to prepare the beaver release are and monitor the population.

Monitoring and evaluation: Extensive and detailed monitoring took place on the site as it was the first legal beaver reintroduction to take place in the UK. Data was collected on biodiversity, water flows, and community impacts to see how the beaver's influenced the landscape.

Nature-based Solutions: focus on soil. Of the databases examined, we found that only just over 9% addressed soil factors. Within those the most common approach was to look at improving soil quality, or to increase the conversion of degraded soil. Many of these look at peatland soil restoration.

Case Study 8 – Slowing the Flow at Pickering

Pickering, North Yorkshire, United Kingdom

The Slowing the Flow at Pickering project demonstrates how integrated catchment-based interventions can significantly reduce downstream flood risk by applying nature-based solutions. A combination of measures, including woody debris dams, riparian and floodplain woodland creation, flood storage bunds, and soil and land management improvements, was implemented across the catchment to attenuate peak flows and increase water storage. Monitoring evidence indicates that these measures contributed to a reduction in peak flows of approximately 15 - 20% during major storm events, with impacts sufficient to prevent flooding to properties during the 2015 Boxing Day event. Overall, the project reduced the probability of flooding in Pickering from around 25% to below 4% annually, demonstrating the potential effectiveness of coordinated interventions at the catchment scale.

Climate change mitigation: Not reported.

Climate change adaptation: By increasing catchment storage capacity and delaying hydrological response, the interventions reduce peak flows and mitigate the impacts of intensifying rainfall events under climate change.

Ecological effect: Not reported.

Socioeconomic outcomes: The project reduced flood risk for downstream communities (40-50 properties), protecting homes and infrastructure while generating wider economic benefits through avoided damages and enhanced ecosystem services

Governance: The project was delivered through a strong multi-stakeholder partnership involving government agencies, research institutions, and local authorities, enabling coordinated catchment-scale planning and implementation.

Finance: The project was funded through a combination of Defra support and partner contributions, with total costs of approximately £4 million, demonstrating a blended public investment model for nature-based flood management.

Monitoring and evaluation: A monitoring programme combining hydrological data, modelling, and field observations has been used to assess effectiveness, although challenges remain in isolating the impacts of individual interventions and establishing long-term evidence.

Where and when NbS are most effective

Common reasons NbS fail to deliver flood-risk reduction

Evidence across UK and international NbS programmes indicates that underperformance most commonly arises from structural and governance failures rather than from the NbS concept itself. Key failure modes include:

- **Insufficient scale of intervention**, where small, isolated projects are implemented without achieving meaningful catchment-wide hydrological impact
- **Lack of integration across measures**, for example, relying on soil interventions without complementary floodplain, wetland, or flow-path measures
- **Poor site targeting**, where NbS are deployed in locations with limited hydrological leverage
- **Short funding horizons**, preventing maturation of ecological and hydrological benefits
- **Weak monitoring and adaptive management**, limiting learning and performance improvement
- **Fragmented governance**, leading to uncoordinated interventions across landholdings

Without addressing these systemic design issues, NbS investments risk generating symbolic environmental benefits while delivering limited measurable risk reduction.

Constraints

The case studies presented in this report demonstrate that Nature-Based Solutions (NbS) can contribute meaningfully to flood-risk reduction and wider environmental co-benefits. However, evidence from UK and international research programmes also highlights a set of recurring limitations and boundary conditions that influence performance, timing, and confidence among regulators, insurers, and financial institutions (Dadson et al., 2017[97]; Burgess-Gamble et al., 2018[4]). Recognising these constraints is essential to avoid over-expectation and misdirected investment, and to support the effective design and scaling of NbS as part of integrated flood-risk management strategies.

Scale and spatial coherence remain critical determinants of effectiveness

Many NbS interventions are implemented at the scale of individual plots, farms, or sub-catchments, while flood risk to properties, SMEs, and infrastructure is driven by hydrological processes operating across entire catchments. Evidence from the UK Flood and Coastal Erosion Risk Management (FCERM) research programme indicates that while local measures often deliver detectable hydrological benefits, these do not consistently translate into downstream reductions in flood probability unless interventions are deployed at sufficient density and spatial coordination (Dadson et al., 2017[97]). NbS are therefore most effective

[97] Dadson, S. J., Hall, J. W., Murgatroyd, A., Acreman, M. C., Bates, P. D., Beven, K. J., et al. (2017). A restatement of the natural science evidence concerning catchment-based "natural" flood management in the UK. Proceedings of the Royal Society A, 473, 20160706. Available here: https://doi.org/10.1098/rspa.2016.0706

when embedded within catchment-scale strategies rather than implemented as isolated measures.

Performance is conditioned by soil state and event characteristics.

Soil-based interventions such as sub-soiling, aeration, cover cropping, and regenerative practices are most effective under moderate rainfall and favourable antecedent moisture conditions. During extreme rainfall events, particularly when soils are already saturated or highly compacted, infiltration capacity can be exceeded, limiting attenuation of flood peaks (Deasy et al., 2014[98]; Dadson et al., 2017[9797]). This does not diminish the value of soil-focused NbS, but it underscores the importance of combining them with complementary measures such as floodplain reconnection, wetland restoration, and flow-path management to deliver resilience across a wider range of conditions (Burgess-Gamble et al., 2018[4])

Temporal dynamics may not align with short-term financial decision horizons.

Many NbS require several years to reach full hydrological and ecological functionality, for example, during woodland establishment or peatland rewetting. Where NbS are framed primarily as short-term flood-defence substitutes, this temporal lag can lead to misaligned expectations among stakeholders, including insurers and lenders. Evidence suggests that NbS are more appropriately understood as long-term risk-reduction assets whose benefits accrue progressively over time (Dadson et al., 2017[97]; Iacob et al., 2017[99]).

Monitoring, attribution, and evidence consistency remain uneven.

Across global and UK NbS datasets, a substantial proportion of projects lack long-term, standardised monitoring. In the absence of consistent baselines, counterfactuals, and sustained observation, it can be difficult to attribute observed changes in flood behaviour to specific interventions rather than to climatic variability (Connelly et al., 2023[100]; Burgess-Gamble et al., 2018[4]). These limitations constrain the development of decision-grade evidence required for insurance pricing, credit risk assessment, and private investment.

Governance and land-manager incentives are integral to long-term performance.

NbS effectiveness is strongly influenced by governance arrangements, tenure, and the socio-economic context of land management. Projects that rely solely on voluntary uptake, short-term funding, or informal agreements are vulnerable to changes in land use, economic pressure, or management priorities. Evidence from NEIRF and FCERM evaluations indicates

[98] Deasy, C., Titman, A., and Quinton, J. N. (2014). Measurement of flood peak effects as a result of soil and land management, with emphasis on experimental issues and scale. Journal of Environmental Management, 132, 304–312. Available here: https://www.sciencedirect.com/science/article/pii/S0301479713007202

[99] Iacob, O., Brown, I., & Rowan, J. (2017). Natural flood management, land use and climate change trade-offs: the case of Tarland catchment, Scotland. Hydrological Sciences Journal, 62(12), 1931-1948. Available here: https://doi.org/10.1080/02626667.2017.1366657

[100] Connelly, A., Lane, S. N., Addy, S., Bracken, L. J., O'Donnell, G. M., & Thorne, C. R. (2023). Evaluating the effectiveness of natural flood management interventions: A systematic evidence map. Sustainable Earth, 6, 13. Available here: https://doi.org/10.1186/s13750-023-00297-z

that NbS outcomes are most durable where long-term agreements, appropriate incentives, and clear governance structures are integrated into project design (Reed et al., 2017[101]).

Taken together, these considerations do not suggest that NbS are ineffective. Rather, they indicate that NbS perform best when designed as system-level interventions, aligned with catchment processes, supported by long-term governance and monitoring, and framed within realistic expectations of performance under extreme conditions. Explicitly acknowledging these limitations strengthens, rather than weakens, the case for NbS by supporting credible, evidence-based deployment at scale.



[101] Reed, M. S., Vella, S., Challies, E., de Vente, J., Frewer, L., Hohenwallner-Ries, D., Huber, T., Neumann, R. K., Oughton, E. A., Sidoli del Ceno, J. & van Delden, H. (2017). A theory of participation: what makes stakeholder and public engagement in environmental management work? Restoration Ecology, 25(S1), 7–17. Available here: https://doi.org/10.1111/rec.12541

Research Gaps and Future Needs

The evidence reviewed in this report demonstrates that Nature-Based Solutions (NbS) can reduce flood risk, enhance ecological resilience, and deliver substantial co-benefits. However, from the perspective of a major UK bank such as Santander, the critical question is not whether NbS can work, but whether they can be translated into decision-grade risk information that supports lending, portfolio management, and regulatory compliance at scale.

Overall, despite the strong evidence from NEIRF and FCERM (as outlined in case study 1), an analysis of databases of NbS in general – from around the UK and elsewhere in the world – finds a worrying lack of published reports that monitor impact. Of 1,781 case studies, only 660 (37%) - confirmed that a formal monitoring system was in place. To reach a point where such interventions are truly investable will require a reduction in the transaction costs associated with monitoring and verification. Despite growing recognition of NbS benefits, only a small proportion of projects are led by private financial institutions. This reflects a structural gap: NbS delivery lacks intermediaries capable of aggregating projects, standardising evidence, and aligning incentives across land managers, insurers, public bodies, and lenders. For Santander, this gap represents both a constraint and an opportunity.

While persistent research and evidence gaps currently limit the integration of NbS into mainstream financial decision-making, below are those we consider as the highest priority research questions for Santander to consider.

1) Scaling and threshold effects relevant to financial risk

A key gap concerns the scale at which NbS deliver meaningful flood-risk reduction. While many studies demonstrate local hydrological benefits, there remains limited evidence on how interventions perform when aggregated across larger sub-catchments or whole catchments, particularly under extreme rainfall and saturated soil conditions. For Santander, this matters because flood risk to mortgage and SME portfolios is correlated, not isolated. Without clearer evidence on the scale and density of interventions required to shift downstream flood probabilities, NbS benefits remain difficult to incorporate into credit risk models, portfolio stress testing, or capital planning.

Research question: *What scale and spatial density of Nature-Based Solutions is required to deliver a measurable reduction in downstream flood probability at the sub-catchment and whole-catchment level?*

Why it matters: Santander's exposure to flood risk is systemic and correlated across regions, not limited to individual properties. Without clarity on the scale at which NbS measurably reduces flood probability, Santander cannot determine when NbS meaningfully lowers expected losses across mortgage and SME portfolios, rather than delivering only localised benefits.

2) Reliability, longevity, and whole-life performance

Bank lending decisions, especially residential mortgages, are based on long time horizons. Yet evidence on the durability, maintenance requirements, and long-term performance of NbS remains limited. Research gaps persist around how quickly interventions become effective, how their performance evolves over time, and how they compare with engineered defences in terms of reliability. For Santander, this creates uncertainty over whether NbS-related risk reduction can be credibly reflected in long-term asset valuations and loss-given-default assumptions.

Research question: *What is the whole-life performance and reliability of key NbS types, including time-to-benefit, maintenance requirements, and failure modes, and how do these align with mortgage and SME lending horizons?*

Why it matters:
Residential mortgages and many SME loans extend over decades. Santander therefore needs confidence that NbS deliver durable, sustained risk reduction over comparable time horizons, and that governance or maintenance failures do not reintroduce risk after lending decisions have been made.

3) Transferability across geographies and asset types

Santander's UK portfolio spans diverse geographies, catchment types, and land-use contexts. However, current NbS evidence remains highly site-specific. There is limited guidance on where particular interventions are likely to be effective, how outcomes vary by soil type, geology, slope, and land use, and how benefits translate from rural headwaters to urban flood exposure. This constrains Santander's ability to prioritise NbS engagement in areas of the most excellent portfolio exposure and to replicate successful models across regions.

Research question: *Under what conditions do soil-based interventions contribute meaningfully to flood-risk reduction, and how must they be combined with floodplain, wetland, woodland, and flow-path measures to remain effective during extreme rainfall events?*

Why it matters:
Soil interventions are often promoted as low-cost NbS, yet evidence shows their flood-risk benefits are partial and highly context-dependent. Santander needs clear guidance on when soil measures contribute to genuine risk reduction and when reliance on soil-only approaches risks overestimating resilience in high-exposure catchments.

4) Translating NbS performance into decision-grade metrics

Managing ecological trade-offs and unintended consequences

NbS interventions interact with complex ecological systems, and trade-offs can arise between flood mitigation, carbon storage, biodiversity, groundwater recharge, and land productivity. Evidence gaps remain around the impacts of large-scale tree planting on infiltration and baseflows, the cumulative effects of "slow-the-flow" measures, and the risks of displacing other ecosystem services or carbon stocks. For a bank operating under increasing ESG and nature-risk scrutiny, a robust understanding of these trade-offs is essential to avoid inadvertently financing interventions that shift risk rather than reduce it.

Transferability across geographies and asset types

Perhaps the most critical barrier to private-sector engagement is the lack of consistent, scalable monitoring and reporting (MRV) frameworks. Across global NbS databases, fewer than 40% of projects report formal monitoring. NEIRF experience highlights that uncertainty around baselines, indicators, and long-term credibility of methods continues to undermine investor confidence. For Santander, MRV is not a technical detail but a prerequisite for integrating NbS into underwriting standards, pricing logic, ESG disclosures, and regulatory reporting aligned with PRA and TNFD expectations.

Research question: *How can NbS performance be translated into decision-grade financial risk metrics used by banks (e.g. probability of default and expected credit loss)?*

Why it matters:
Credit decisions, capital allocation, and stress testing depend on quantitative financial risk metrics. If NbS outcomes cannot be translated into these measures, their risk-reduction value cannot be reflected in underwriting, pricing, portfolio strategy, or regulatory reporting, limiting Santander's ability to integrate NbS into core risk management.

5) Financial valuation and avoided-loss evidence

While benefit–cost ratios for NbS are often favourable at a societal level, there is limited evidence that directly links interventions to avoided financial losses for lenders and insurers. Santander requires valuation approaches that connect NbS performance to reduced default risk, stabilised collateral values, and insurance affordability. Without this link, NbS remains peripheral to core financial decision-making rather than embedded within it.

There is a research gap in the economic quantification of co-benefits. There is substantial evidence of productivity benefits, including improved livestock growth rates and reduced mortality from shelter. However, the co-benefits of interventions to improve soil health and reduce flood risks, such as improved crop growth and livestock productivity, have not yet been meaningfully economically quantified. For example, modelling the economic advantages of

agroforestry and windbreaks requires additional quantitative data to validate and improve them (Jordon et al., 2020[76]; Baker et al., 2018[102]).

***Research question**: How much catchment-scale risk reduction is required to stabilise insurance availability and affordability, and what does this imply for mortgage affordability, SME continuity, and correlated credit risk?*

Why it matters: Insurance availability and cost are critical to mortgage viability and SME resilience. As insurers adjust premiums, exclusions, and coverage in response to rising flood risk, NbS that demonstrably reduce hazard severity may help stabilise insurance markets. Understanding this relationship allows Santander to anticipate emerging portfolio stress and support upstream risk reduction that protects long-term asset value.
By addressing critical research gaps (outlined above), Santander has an opportunity to strengthen resilience across its lender portfolio and lead the way in mobilising private finance for NbS. Addressing these gaps would enable Santander to move from exploratory engagement with NbS to systematic integration within its risk management and product strategies.

In summary, the priority areas for evidence improvement are:

- Decision-grade evidence that links NbS interventions to financially material risk metrics.
- Scalable MRV systems that reduce transaction costs and support portfolio-level analysis.
- Catchment typologies that help prioritise engagement where Santander's exposure is highest.
- Whole-life performance data aligned with mortgage and SME lending horizons.
- Intermediated delivery models that blend public funding, insurance mechanisms, and private finance.

102 Baker, J. P., Morton, M., Mendham, D. S., Smith, R. & Hunt, M. A. (2018). Impacts of windbreak shelter on crop and livestock production. Crop and Pasture Science, 69(8), 785–796. Available here: https://doi.org/10.1071/CP17242

Policy and Market Implications & Recommendations

UK Nature Policy

Currently, UK government policy frames natural capital and nature-based solutions as core to meeting environmental, economic and climate goals, as does embed them in planning, funding and long-term strategic frameworks. Central to this approach is the Environmental Improvement Plan (EIP) - a refreshed roadmap to restore and enhance the natural environment with measurable targets, such as creating or restoring 250,000 ha of wildlife-rich habitat by 2030 and boosting tree cover and connected ecosystems that deliver benefits including carbon storage, improved water quality and natural flood management.

Two particularly relevant nature policies for the reduction and management of flood risk, one might add, are firstly Biodiversity Net Gain legislation (which commits property developers to a 10 % enhancement in biodiversity, compared to pre-development baselines. Secondly, as announced in the 2025 Spending Review, the government's Nature Recovery Plan commits around £2.7 billion annually to sustainable farming and nature recovery programmes, alongside £4.2 billion over three years for flood defences – a mix of traditional infrastructure and nature-based measures designed to reduce flood risk, while supporting ecosystems that act as natural buffers.

However, while current policies show a growing awareness of nature-security risks among UK policymakers, interventions are potentially too slow to avoid serious harm – particularly for homeowners and lenders. The government's current commitment to building new homes, for example, could mean that the implementation of a 10% Biodiversity Net Gain is fairly limited in impact. Currently, BNG only applies to large developers, those developers can outsource their biodiversity gain to farmers or land-owners in other regions, and the scheme's lack of maturity makes it relatively unproven in practice, with loopholes yet to emerge. Critically, the flood benefits of such nature recovery schemes (if successful) will not take effect for years and could offer little compensation if new homes continue to be built on floodplains (as discussed in Chapter 1).

In that context, it is likely that pressure on Santander from insurers and homeowners will outpace policy solutions implemented by government, without further intervention.

A good example of this is the Flood Re scheme, currently underwritten by the UK government. While Flood Re has been critical in maintaining short-term insurance availability for high-risk households, its role is transitional rather than permanent, with the scheme currently scheduled to end in 2039. As climate change intensifies flood hazards, long-term insurance market sustainability will increasingly depend on demonstrable reductions in underlying risk rather than continued risk redistribution. In this context, NbS offer a structural risk-reduction mechanism capable of supporting future insurability by lowering flood frequency and severity at source. Without such upstream investment in landscape resilience, pressure on insurance affordability and market withdrawal is likely to increase, with direct consequences for mortgage viability and financial stability.

This creates a critical question for Santander: how can the bank leverage its risk frameworks, partnerships, and financing capabilities to help shift the UK from reactive loss repair to proactive risk reduction at source? The policy and market landscape is increasingly supportive of catchment-scale approaches. Still, investment will only scale where there is confidence in outcomes, transparency of data, and mechanisms that align incentives across land managers, regulators, insurers, and financial institutions. Ultimately, and particularly where policy interventions might move too slowly, Santander should feel encouraged to move from passive exposure to actively shaping and mitigating risk.

The following recommendations, based on our evidence, highlight where Santander could choose to focus investment and resource:

Catchment level: Recognise, and build, NbS partnerships as financial infrastructure

The evidence shows that NbS succeeds where governance is collaborative and locally embedded. Catchment-based partnerships provide a mechanism to align land managers, communities, regulators, and delivery bodies. For Santander, engaging through such partnerships offers a way to support risk reduction without becoming a delivery organisation, while gaining access to shared data, coordinated action, and cumulative impact.

As a primary mortgage lender and business bank, Santander is not merely exposed to flood risk; it plays a role in shaping how that risk accumulates across landscapes. Lending decisions influence development patterns, land management incentives, and the resilience of households and businesses. NbS are particularly relevant because they address risk at source, reducing the likelihood of correlated losses across entire communities rather than protecting individual assets in isolation.

Beyond partnership engagement with NbS at the delivery level, Santander should increasingly seek partnerships with insurers, actuaries, and delivery partners to integrate NbS projects and metrics within risk management mechanisms. The growing interest in parametric insurance and alternative risk-transfer mechanisms highlights an opportunity for closer alignment between banks, insurers, and NbS delivery. Catchment-scale NbS that demonstrably reduce flood risk can underpin more affordable insurance, stabilise mortgage affordability, and reduce systemic exposure. Santander is well placed to explore such models in collaboration with insurers and public partners.

Research Gaps - Develop and Integrate the Evidence Base

Santander should evaluate the research gaps outlined in the section above and pursue investment accordingly, as an opportunity to build the UK's stock of flood-resilient natural capital, meet future regulatory requirements, and develop pioneering partnerships with regulators, lenders, and insurers.

When evaluating these, Santander should consider the credibility of an NbS scheme cannot depend on waiting decades for long-term ecological outcomes. Instead, credible schemes at completion should demonstrate:

- **Sufficient scale and spatial coherence** relative to the catchment's hydrological dynamics.
- **Clear governance arrangements**, including long-term stewardship responsibilities;
- **Integrate MRV with defined performance indicators.** The next phase of NbS scaling will be driven less by new pilots and more by data infrastructure. Santander's ability to integrate NbS into lending and risk models depends on credible MRV. Supporting standardisation directly or through partnerships would help turn NbS from an ESG narrative into a financeable asset class.
- **Integration with wider catchment management strategies,** not stand-alone delivery.
- **Evidence-informed design**, drawing on hydrological modelling and prior case performance.

Where these conditions are met, Santander's investment and partnership facilitation can not only address critical evidence gaps but increase the recognition among insurers and regulators that such investments are legitimate risk-reduction infrastructure rather than experimental environmental projects.

Policy Alignment and Intervention

UK policy increasingly emphasises catchment-scale approaches, partnership delivery, and working with natural processes. At the same time, regulators are sharpening expectations around climate- and nature-related risk management. NbS offer Santander a practical pathway to demonstrate proactive risk mitigation aligned with PRA climate guidance, TNFD-style disclosures, and broader ESG commitments – provided the supporting evidence is robust.

For Santander, these shifts indicate that NbS will increasingly serve as core climate-risk infrastructure rather than as discretionary sustainability activities. However, realising this transition at scale depends on targeted policy reform that enables systemic investment models. To support Santander's financial-sector engagement and a resilient flood mitigation strategy that protects revenue, Santander could explore and potentially advocate for government policy that:

1. **Recognises NbS as climate-resilience infrastructure within public investment and regulation.** NbS should be formally embedded within national flood risk management, climate adaptation strategies, and infrastructure planning frameworks — alongside engineered defences.

   Suggested action: Encourage government to classify catchment-scale NbS as eligible resilience infrastructure for public co-investment, blended finance, and long-term capital programmes.

2. **Mandates integration of catchment risk data into local planning and financial supervision.** Climate-adjusted flood risk, NbS deployment, and catchment resilience metrics should inform development approvals, mortgage risk models, and insurance capital assessments.

   Suggested action: Lobby planning authorities and regulators to incorporate system-scale climate risk and nature-based mitigation into decision-making and risk stress testing.

3. **Oversees national NbS database and monitoring infrastructure**
   Fragmented project-level evidence limits financial confidence and increases transaction costs.

   Suggested action: Santander could either encourage government to mandate, or work with a consortium of private sector and policy partners to fund shared catchment-scale monitoring platforms that link hydrology, ecosystem performance, and avoided-loss metrics accessible to banks, insurers, and investors.

4. **Links insurance market reform to upstream risk reduction**
   Long-term insurability cannot rely solely on risk redistribution. Particularly with Flood Re due to close in 2030, Santander should play an active role in working with government and insurers on the post-2030 solution, ensuring this protects the lenders and homeowners voice.

   Suggested action: Encourage government to introduce mechanisms that reward investment in NbS through insurance pricing, capital relief, or resilience-linked incentives tied to demonstrable risk reduction.

Appendix 1: Featured case studies comparison

No	Catchment / Project	Location	Catchment Size	Key NbS Measures	Implementation Cost	Estimated Avoided Damages	Assets Protected	Outcomes	Funder
1	**Hill Stone Wood (NEIRF NbS Insurance Financing Model)**	United Kingdom (multiple catchments: Ancholme, Dorset Stour, Ouse & Adur, Wyre)	Multiple catchments	Financing NbS through green home insurance brokerage; funding NFM measures, including swales, permeable surfaces, wetlands and runoff attenuation	Funded through insurance revenue (reinvesting ~80% of profits into NbS)	Not quantified	Not quantified	Innovative financing model linking insurance markets to catchment-scale NbS investments; aims to create long-term funding streams for flood mitigation and ecosystem services	NEIRF Case Study – Hill Stone Wood
2	**Eddleston Water River Restoration for Natural Flood Management**	Scottish Borders, UK	~69 km²	3 km river re-meandering; 200+ ha native woodland planting; cross-slope hedgerows; 116 log barriers; 28 flood storage ponds; floodplain reconnection; embankment removal	~£3.5M (Scottish Government programme estimate)	~£950,000 avoided flood damages	~500 properties downstream	Flood peaks reduced by ~30% and delayed >4 hours; improved river ecology and fish habitat; WFD ecological status improved from "bad" to "moderate"	Tweed Forum / Scottish Government NFM Programme
3	**Million Metres Streams Project (non-UK)**	New Zealand (nationwide catchments)	Multiple waterways	Riparian native planting, wetland restoration, erosion control, waterway restoration	~$2.3M raised to date; target ~$10M over 5 years	Not quantified	Not quantified	Improved water quality, erosion reduction, wetland restoration supporting flood mitigation and water storage; community-led restoration and corporate engagement	Sustainable Business Network – Million Metres Streams Project
4	**Wallasea Island Wild Coast**	Essex Estuary, United Kingdom	~115 ha restored tidal habitat	Managed realignment; saltmarsh and mudflat creation; lagoon restoration; reuse of ~3 million tonnes of excavated material from Crossrail; seawall breaching and floodplain reconnection	Major project funding from Crossrail, Environment Agency and partners (exact total not specified)	Reduced long-term seawall maintenance costs estimated between £650k and £5–10M over 10 years	Coastal properties west of the island	Creation of 115 ha tidal habitat; improved coastal flood protection through saltmarsh formation; carbon sequestration ~2 tCO_2/ha/year; designated Ramsar and Special Protection Area for migratory birds	RSPB; Crossrail; DEFRA; Natural England
5	**Swindale Beck River Restoration**	Cumbria, United Kingdom	~1,000 ha catchment restoration area	Re-meandering 1,140 m of straightened river channel; peat bog restoration (~1,000 ha); restoration of 15 ha species-rich hay meadow; catchment vegetation restoration	~ £212,500	Not monetised, but flood risk reduction benefits reported	~150 properties downstream (Eamont Bridge)	Slower water flow through valley reducing downstream flood risk; improved raw water quality into Haweswater Reservoir; restored spawning habitat for Atlantic salmon; increased biodiversity and habitat complexity	RSPB; United Utilities; Environment Agency
6	**Meuse (Grensmaas) River Restoration and**	Netherlands / Belgium border	~45 km restored river corridor	River widening and rewilding; floodplain creation; gravel extraction integrated with	~€550M	Not monetised directly	Communities along the Meuse floodplain	System designed for 1-in-250-year flood events; restored floodplain capacity prevented damage to nearby houses	Consortium Grensmaas Natuur

	Floodplain Creation			restoration; natural grazing (~200 ha); reintroduction of beaver and otter				during 2021 floods; strong ecological recovery and tourism benefits (~2 million visitors annually generating ~€1B regional revenue)	monument enten
7	**River Otter Beaver Reintroduc-tion Trial**	Devon, United Kingdom	River Otter catchment (~250 km²)	Beaver reintroduction creating natural dams; wetland and pond creation; sediment trapping and water storage	Not publicly specified	Not monetised	Downstream villages in the Otter catchment	28 beaver dams created over four years; ~2 km of river impounded forming wetlands; reduced flood peaks, improved water quality, increased biodiversity including water voles, amphibians, trout and lamprey	Devon Wildlife Trust; Natural England; University of Exeter
8	**Potteric Carr Wetland Expansion**	Doncaster, United Kingdom	~75 ha restored wetland	Conversion of arable land to wetlands; creation of interconnected reed beds, lagoons and water bodies; restoration of historic wetland landscape	~£1M	Not monetised	Not specified	Restoration of 75 ha wetland habitat improving water storage and reducing local flood impacts; improved water quality for nearby communities; enhanced breeding habitat for waders and wildfowl; contribution to local visitor economy	Yorkshire Wildlife Trust; WWF; HSBC Investing in Nature partnership
9	**Headwater Meadow and Trout Stream Restoration (Maggie Creek, Crow Creek, Wasson Creek)**	Nevada, Idaho, Montana – United States	Multiple headwater catchments	Riparian tree restoration; wetland and meadow restoration; river re-meandering; deep pool creation; floodplain reconnection; improved livestock management in riparian zones	Not specified	Not monetised	Not specified	Restored wetlands and meanders slowed flows, reduced sedimentation and bank erosion, increased groundwater recharge, and lowered peak water temperatures; improved trout populations and aquatic ecosystem health	Trout Unlimited; Bureau of Land Management; National Fish and Wildlife Foundation
10	**Backwaters Management in Augsburg City Forest (Stadtwald Augsburg)**	Augsburg, Bavaria, Germany	~300 ha managed biotope landscape	Grazing management (sheep, red deer, Przewalski's horses); mowing and scrub clearance; restoration of lime-dry grasslands on gravel banks; habitat regeneration and early soil stage creation	~ €249,752 (50% funded by German Federal Environment Foundation)	Not quantified	Not specified	Management of 300 ha urban forest and riverine habitats improving ecological resilience, maintaining gravel-bank grasslands and supporting biodiversity in the Augsburg Stadtwald nature reserve	Augsburg Landscape Care Association; German Federal Environment Foundation
11	**Garron Plateau Peatland Restoration**	County Antrim, Northern Ireland, UK	Largest peat bog in Northern Ireland	Peatland re-wetting; construction of thousands of peat, timber and stone dams to block drainage channels; grazing pressure reduction through agreements with farmers	Public funding from EU and Northern Ireland government (cost not specified)	Estimated £37M total ecosystem service value by 2045; £55,953/year reduction in flood damages; £4,158–£17,325/year reduction in water treatment costs	Not specified	Restoration expected to deliver 27% improvement in flood mitigation capacity (6.3% across catchment); shift from net carbon source to sink (+17,918 tCO_2e/year change); improved water quality and peatland biodiversity	Northern Ireland Environment Agency; NI Water; RSPB

12	**Sompting Catchment Muddy Flood Mitigation**	South Downs, United Kingdom	~100 ha restored grassland	Conversion of arable land to permanent grassland; soil erosion control on vulnerable slopes; catchment land management changes	Funded through EU Common Agricultural Policy and UK Government programmes	Not monetised	Town of Sompting and nearby housing estates	Significant reduction in muddy floods, soil erosion and surface runoff; much lower frequency of flood events even during wet years	UK Government; CAP-funded catchment restoration studies

Appendix 2: Additional case studies

Case Study 9 – Backwaters management in the city forest

Germany

Management of natural lime-dry grasslands on gravel banks in Augsburg is conducted by the Landscape Association of the City of Augsburg in Bavaria. 300 ha of biotopes within the municipal area is maintained due to sheep grazing, mowing management, scrub clearance and reopening of potential expansion areas as well as further activities to create initial stages of immature soils.

Climate change mitigation: not reported

Climate change adaptation: not reported

Ecological effect: protection and enhancement of pre-alpine pine forests on river gravel in the nature reserve Stadtwald Augsburg, with red deer and Przewalski's horses grazed.

Socioeconomic outcomes: not reported

Governance: Augsburg Landscape Care Association (Landschaftspflegeverband City of Augsburg e.V.) conducted management and oversaw the process of regeneration. The ALCA is sponsored by the German Federal Environment Foundation for four years.

Finance: the calculated total project costs amounted to € 249,752.50. The requested funding share was 124,876.25 € (corresponds to 50%)" (Ref. 8).

Monitoring and evaluation: comprehensive, formal EU-driven monitoring plan is ongoing.

Case Study 10– Restoration of trout streams, riparian habitat and watersheds

United States

In three locations in the Western USA - Nevada, Idaho and Montana – restoration efforts to address the impact of climate change on trout habitat have taken whole-landscape approaches, including restoring headwater meadows and wetlands, riparian habitat and floodplain areas.

Maggie Creek, Nevada; Crow Creek, Idaho; and Wasson Creek, Montana have seen restored riparian trees and the number and size of deep pools were increased. Headwater meadows and wetlands were restored in order to keep flows in headwaters longer, serving to mitigate the effect of earlier peak flows. Natural meanders were restored and recreated, slowing the flow of water, reducing sedimentation and bank erosion and recharging aquifers which help to mitigate the effects of increasing summer droughts. The work also included improved livestock management near riparian zones.

Climate change mitigation: Not reported

Climate change adaptation: The study reported positive outcomes for climate change adaptation, including reduced peak water temperatures in summer heat waves, less riverbank erosion, and higher groundwater levels from recharged aquifers.

Ecological effect: The study reported measuring higher trout populations after the interventions, as well as increases in larger fish. Ecosystem health of the surrounding riparian and wetland habitats was reportedly improved, providing benefits for other species.

Socioeconomic outcomes: While not explicitly reported, higher trout populations can benefit local communities who fish the trout.

Governance: This project is governed by a vast multi-agency coalition that works across state borders while also working with local landowners on issues such as localized grazing pressures.

Finance: Funding was provided by the National Fish and Wildlife Foundation, The Bureau of Land Management , Trout Unlimited (TU), Barrick Goldstrike Mines Inc., the Nevada Mining Association, the U.S. Forest Service, National Forest Foundation, Idaho Department of Environmental Quality, and the Simplot Corporation.

Monitoring and evaluation: Multiple organizations such as The Bureau of Land Management and Trout Unlimited took part in monitoring efforts to study the health to the restored creeks and trout populations.

Case Study 11 - Peatland restoration to protect water supplies in the Garron Plateau

United Kingdom

In Country Antrim, Northern Ireland there has been extensive work to restore the Garron Plateau containing the largest area of peat bog in Northern Ireland. Through activities such as building thousands of small timber, peat and stone dams to block drains and ditches and negotiating agreements with local farmers to reduce the pressures from livestock grazing, the initiative aims to have the entirety of the site returned to a favourable condition by 2045.

Climate change mitigation: Shallow peat habitats are able to sequester carbon, and thus the restoration of the Garron Plateau is expected to lead to a net sequestering of carbon by 2045. By then and after full restoration, the area is estimated to sequester 1,146 tCO2e/yr, going from a net emitting to a net sequestering landscape, an overall change of 17,918 tCO2e/yr compared to 2010, for an estimated monetary value of £1,386,978.

Adaptation: Increased quality of ecosystem services provisioning, notably freshwater supply, which reportedly experienced a decrease in discolouration, turbidity (cloudiness) and dissolved organic carbon, lowering water treatment costs. It is predicted that by 2045, the project will achieve a 27% improvement in flood mitigation capacity (a 6.3% improvement across the catchment). Furthermore, the study has estimated a reduction of £55,953 per year in average annual damage costs, as well as a reduction range of £4,158 – £17,325 per year in water treatment costs.

Ecological effect: The re-wetted bog is expected to have more ecological resilience, with the restored habitat likely providing benefits to the diverse flora and fauna, including critically endangered species of moorland birds such as the hen harrier, merlin and curlew and rare plants such as the marsh saxifrage and bog orchid.

Socioeconomic outcomes: The peatland restoration led to significant improvements in water quality, helping lower the cost of water treatment for surrounding communities.

Governance: The project was the result of a collaboration among the Northern Ireland Environment Agency, Northern Ireland Water, the RSPB, and local farmers.

Finance: Initial funding for this project was from public sources (EU and NI government). The predicted value of the total benefits of the project is estimated to be £37 million by 2045, with the most value attributable to increased climate mitigation capacity, complemented by increased quality water provisioning and ecological resilience of the area.

Monitoring and evaluation: This area is designated as a Ramsar site, which has allowed for expanded monitoring and evaluation on the site location to take place.

Case Study 12– Curtailment of muddy floods in the Sompting catchment area

United Kingdom

The conversion of agricultural land to grassland and other management changes resulted in a drastic reduction of muddy floods, soil erosion and runoff in the Sompting catchment area in the South Downs of the UK. In 1992, around 100 hectares of agricultural land, mainly located on slopes vulnerable to runoff and erosion, were permanently set aside to revert back into grassland. Prior to these changes, the area and town of Sompting experienced intense flooding and excessive soil erosion in the 1980s and early 1990s. Much less frequent flooding events were observed after the intervention, even in particularly wet years, according to ongoing monitoring.

Climate change mitigation: Not reported.

Climate change adaptation: The restoration of permanent grassland cover on slopes vulnerable to erosion in a catchment area prone to flooding has reportedly effectively reduced the frequency and impact of flooding during heavy rainfall events, which are expected to intensify due to climate change.

Ecological effect: Not reported.

Socioeconomic outcomes: The housing estate that the study observed, as well as the town of Sompting and other areas in the catchment, reportedly benefited from a significantly reduced risk of flooding, particularly highly damaging muddy flooding.

Governance: The UK Government currently manages the land.

Finance: The purchase and restoration of the land was funded by the European Union Common Agriculture Policy and the UK Government.

Monitoring and evaluation: Some scientific studies have evaluated the impacts of the catchment restoration, but surveys tend to be irregularly conducted.

Appendix 3: Additional NbS case studies comparison

No	Catchment / Project	Location	Catchment Size	Key NbS Measures	Implementation Cost	Estimated Avoided Damages	Houses / Assets Protected	Outcomes	Funding comes from
1	New Forest LIFE III Project	Hampshire	Total length of Lymington River (49km), Avon Water (45km) and Hampshire Avon (1,750km) But project was about Multiple headwater catchments (Lymington River, Avon Water) 10km of river 604ha of forest and wetland habitats restored	Re-meandering straightened rivers (10 km), floodplain reconnection, large woody material, wetland restoration, riparian woodland restoration	£2.9 million	Not quantified directly	Not quantified	Flood peak magnitude reduced ~21% and flood peak travel time increased ~33% for small events (~2-year return period); restoration of 261 ha riparian woodland, 184 ha valley mires, 141 ha wetlands	Hampshire County Council, Natural England, Environment Agency, Forestry Commission, Hampshire County Council, The National Trust, RSPB and University of Southampton
2	Mayes Brook river restoration, Mayes brook park, east London	East London (Barking & Dagenham)	~45 ha park catchment	1.6km river restoration 1.5ha floodplain storage backwater SUDS areas/wetland features 3ha woodland	£750.000	~£27M lifetime ecosystem service benefits	Local residential areas around Mayes Brook Park	Increased flood storage (~1 ha); reduced local flood risk; benefit-cost ratio ~7:1 Maintenance cost: £5,000 per year	Funders included: London Borough of Barking and Dagenham, Environment Agency, Thames Rivers Trust, RSA (insurance), Natural England, Greater London Authority, SITA Trust, London Wildlife Trust, Defra
3	River Avon Restoration Project	Hampshire / Wiltshire	Total area of catchment is 1,750km2, c but in this project: 150km of direct improvement but the 300km of the SSSI and SAC will receive overall improvement	Floodplain reconnection, wetland restoration, water level management, habitat restoration	£4.3 million (funding Phase 1 of the Environment Agency contribution to wider catchment improvement)	Not quantified	Not quantified	Restoration of wet grasslands improves natural water storage and attenuates flood flows across floodplain landscapes	Avon Valley restoration report
4	River Frome Rehabilitation Plan	Dorset	Frome, 109km2 Frome catchment floodplain 19km of direct improvement 50km of the SSSI will receive overall improvement	Floodplain reconnection, wetland creation, river restoration, habitat management	£850,000	Not quantified	Not quantified	Increased floodplain storage and improved ecological functioning support natural	Dorset Frome restoration report

								flood attenuation	
5	River Glaven, North Norfolk	Norfolk	Total area of the catchment is 115 km², but the length of the river restored/reconnected is 400m at Hunworth Meadows	River re-meandering, wetland restoration, and reconnection of historic channels	£10,000 to 50,000	Not quantified	Not quantified	Improved hydrological connectivity and floodplain storage	River Glaven Conservation Group report
6	Chelmer Valley Local Nature Reserve	Essex	The Chelmer catchment is 988 $km^{2.}$ but this project is approximately 2km	River restoration, floodplain reconnection, wetland habitat creation	£25.000	Not quantified	Not quantified	Enhanced floodplain water storage and improved river morphology supporting natural flood attenuation	Chelmer restoration report
7	Mill Brook Tattenhall, Cheshire	Derbyshire	Small upland around the catchment 16km² with a river length of 230m	Leaky dams, woody debris structures, and riparian planting	£ 13,500	Not quantified	22 properties and a main road will benefit from this intervention	Reduced peak runoff and improved catchment water retention	Mill Brook NFM report
8	St Austell Bay Resilient Regeneration Project (StARR), Cornwall	Cornwall, United Kingdom	Par- 32km2 (upper) 11km2 (lower) Sandy River - catchment size but 7km of river restoration used here	7km of river restoration • 30ha of habitat creation and restoration • storage in the catchment equivalent to 400 Olympic-sized swimming pools	Not publicly specified	Not quantified	Communities in St Austell downstream	Slowed surface runoff and reduced peak flows in the catchment; improved catchment water storage and reduced flood risk to the town	Cornwall Council, Environment Agency; Westcountry Rivers Trust

9	Eddleston Water Project	Scottish Borders, UK	75 km²	Remaindering, flow restricting log jams, native tree planting (riparian, hillslope, floodplain and transverse strips), storage ponds, removing artificial banks	£1.4 million	~£950,000 avoided flood damages	527	• Riparian new native woodland: 142ha (~200,000 trees) • Leaky ponds: 22 (8,155m2) • Transverse hedges: 2,305m • High flow restricting log jams: 101 • 2.2 km of river remeandered • 2.900m of floodbank removed	Scottish Government, Building with Nature (Interreg) SEPA, Scottish Borders Council, SNIFFER, Forestry Commission Scotland, Environment Agency, Dundee University, Woodland Trust, Cheviot Futures 2, Scottish Power, CEMEX, Scottish Rural Development Programme, Forest Carbon and Landowner Contributions
10	Padgate Brook River Restoration part of the Warrington FRM Scheme	Warrington, United Kingdom	Padgate Brook, 5km² where 500m of river was restored	Floodplain reconnection, wetland creation, woodland planting, river restoration, runoff attenuation features	£250,000	Not monetised	226 properties	The cost–benefit ratio for the overall scheme is 18	FCRM Grant in Aid and contribution from Warrington Borough Council
11	Low Stanger Floodplain Reconnection Project	North Yorkshire, United Kingdom	Cocker catchment is 148 km2 but here subject is 500m of river, and 5ha of land	Flood embankment breaches to provide floodplain storage Hedges and coppice on floodplain to further slow the flood flow	£4000	Not monetised	Downstream communities in the Swale catchment	Flood embankment breaches to provide floodplain storage Hedges and coppice on floodplain to further slow the flood flow	River Restoration Funding – funnelled through the Environment Agency and Natural England

12	Slowing the Flow at Pickering	Pickering, North Yorkshire, UK	Pickering Beck (69km2) and River Severn (92km2). The series of land management measures are expected to benefit most of the 69km2 of the Pickering Beck catchment. The more restricted nature of the measures within the River Seven catchment means that a much smaller area of this larger, 92km2 catchment is affected (10–15%).	Flood storage bund Timber bunds Large woody debris dams Drain blocking Woodland planting and felling control Moorland no-burn buffer zones Heather reseeding Erosion control Soil aeration Farmyard and road/track works	~£4 million	Risk of flooding in Pickering reduced from a 25% chance in any year to a less than 4% chance. How to quantify further?	50	One large flood storage bund was constructed plus 2 timber bunds, 167 large woody debris dams and 187 heather bale check dams. 29ha of riparian woodland and 15ha of farm woodland planted 5.9ha of riparian woodland restored and forest site operational plans revised 3.2ha of heather moorland reseeded 800m of eroding footpath restored Mixture of roof, yard and related works carried out on 10 farms	Project management, co-ordination, research and reporting were primarily funded by Defra (£480,000 over 6 years). Match funding from partners for project support and implementation of measures totalled around £3 million over 6 years. Additional costs were involved in completing the main flood storage bund in summer 2015. Longer term project management, monitoring and evaluation costs are £20,000–£30,000 per year and are primarily funded by the Forestry Commission. Risk of flooding in Pickering reduced from a 25% chance in any year to a less than 4% chance.
13	Stroud Rural SuDS Project: Community Engagement in NFM	Stroud, Gloucestershire, UK	Frome catchment, 250km2 (total catchment)	Large woody check dams, Earth bunds, and retention pools	£315,000		112	Not specified standard of protection has been set for the project – the aim is to reduce flood risk for those residents at Very Significant <5% annual equivalent rate (AER)	The project officer post has been funded by the RFCC through the Local Levy