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Financing Adaptation and Resilience in London and the UK: Moving from Aspiration to Reality
Part III – Policy Recommendations

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About This Paper

Based on insights from industry, this paper is the final part of the research project: “Financing Adaptation and Resilience in London and the UK.” The project identifies and discusses drivers and challenges for investing in adaptation and resilience and necessary changes for developing capital market solutions in London and the UK. This research has been conducted by the Centre for Climate Finance & Investment (CCFI) at Imperial College Business School and the Singapore Green Finance Centre, following papers focusing on adaptation and nature financing (Buhr, B. (2022); Holtedahl, P., Köberle, A. & Koci I. (2023); Whittaker, S. & Nguyen, T. (2023)).

The research project, divided into three separate papers, takes a practical approach by focusing on the real estate and water sectors in London and the UK, ensuring the findings are directly applicable locally, while also resonating within a broader global context, especially in South East Asia.

Part I Case Studies Analysis of the research project highlights various adaptation and resilience investment and financing models, with eight case studies in London and the UK. The analysis responds to the following three questions: What is the investment proposition and the role of the private sector in adaptation and resilience? What are the main investment models and financing instruments for private investors in these areas? What are major investment drivers for institutional investors such as pension funds and insurers?

Part II Urban Adaptation Financing delves into the current state of adaptation finance in London, making a comparison with Copenhagen and Singapore. This comparison is particularly significant as it allows us to draw lessons from cities with different approaches and experiences, thereby enriching our understanding of urban adaptation financing. The research primarily focuses on private investment and aims to learn about the experience of London (covering the greater London area) in the delivery of climate finance and financing for urban climate change adaptation and understand the potential barriers and opportunities to mobilising finance. The research question ‘To what extent can cities and investors build for innovation in climate adaptation in cities?’ aims to inform and promote a better understanding of financing for climate change adaptation actions.

Part III Policy Recommendations develops policy recommendations taking into consideration the current policy context. Drawing on insights from the case studies analysis and the London urban adaptation finance research (Part I and II of this research project), this paper develops several recommendations, addressing policymakers, regulators, and the financial industry—primarily banks, asset managers, exchanges, and marketplaces. Several recommendations need to be addressed simultaneously to enable private investment into adaptation in London and the UK and these activities need to be embraced by all actors: investors, regulators, Government, Ofwat, The Bank of England, standard setting agencies, corporations, and development companies etc.

This paper has been reviewed and comments were provided by Francisco Martes Porto Macedo (Urban Financing, Climate Policy Initiative), Enrico Isnenghi (Water Environment Department Manager, Sweco UK) and Dr Pernille Holtedahl (Centre for Climate Finance and Investment at Imperial College London).

Summary Policy Recommendations

Drawing on insights from the case studies analysis and the London urban adaptation finance research (Part I and II of this research project), this paper develops several recommendations. The research highlighted areas for change, including regulation & policy, impact measurement, commercialisation of adaptation and knowledge.

Our recommendations aim to scale the adaptation market in London and the UK more generally and include changes such as tax incentives, compliance regulation, vesting a value in adaptation, as well as market activities such as education, co-investment, instilling a sense of urgency in the market, and industry networks. The aim is to create a regulatory and policy environment and industry structure such that it is easier to identify financial returns, bigger project size, more liquidity, higher bankability, investment-ready projects, income streams, and use public finance for de-risking and blended finance.

Given that the priority areas cut across many actors, where possible, these recommendations specify the lead actor best placed to lead their implementation. The recommendations are divided into four interconnected categories of action (see Table 1).

1. Market creation: A market that values adaptation and resilience
2. Delivering Adaptation: Investment Models and financial instruments
3. Mobilising Private Sector Financing
4. Nature, Knowledge Systems and Capability at Local level

Within these key areas, actions for the following include: (I) Market Creation: asset planning, mainstreaming, standards, valuation, and cost-benefit measurement; (II) Adaptation Investment: business models, aligning with carbon markets, resilience standards and green/adaptation bonds; and (III) Sector Mobilisation:: risk assessment, disclosure, and specialised investment vehicles and ultimately for Knowledge and Capability, AI and data analytics, integration of nature in built environment and local financing solutions.

The first section of this policy brief summarises the key findings from part I and II of this research project with policy implications in the current context. The next sections cover all the recommendations in more detail.

Table 1: Recommendations on markets, investment models, sector mobilisation and knowledge

(I) MARKET CREATION: A MARKET THAT VALUES ADAPTATION AND RESILIENCE	
Existing opportunities to invest in adaptation and resilience	
Building resilience infrastructure	• Government encouragement for companies and infrastructure providers to have an active role in facilitating the use of nature-based solutions to help companies better manage the risks from climate change (Govt.). • Allow expenditure in the 2024 water price review (PR24) on resilience and make public the performance commitments from PR19 related to operational resilience improvement (Ofwat) • Encourage water companies to increase their focus on long-term business plans, by requiring the submission of long-term delivery strategies alongside their 5-year business plans, (Govt. & Ofwat) .
Leveraging Planned Investment for Transition and Housing	• Integrated approach to mitigation, adaptation and nature in both policy and investment, leveraging investment planned investment flows for Transition Plans - to be resilient to future climate conditions or future social housing expenditure needed in London (Govt.). • Mandating Biodiversity Net Gain for developers and Nationally Significant Infrastructure Projects, for example aiming to make Sustainable Drainage Systems (SuDS) mandatory in new housing developments in 2024 (Govt.)[1]. • Building on CCRA3, CCC/CCRA4 estimate current government adaptation spending and provide a detailed assessment of adaptation costs for England/UK.
Mainstreaming adaptation & climate proofing investments	
Asset management & planning	• Prioritise maintenance and renewal of the existing infrastructure network (i.e. energy and transport) ensuring resilience to climate change impacts (Govt.). • Monitor companies' asset health and operational resilience and incentivise approaches to long-term asset planning. Require reporting and publication including information on asset management maturity (infra network regulators). • Improve companies' approaches to risk management uncertainty and long-term planning (Corporations).
Resilience planning technical standards	• Require regulators in their current/future water sector price determinations to ensure regulatory settlements are consistent with operators meeting stringent resilience standards in the short and longer term (See Recommendation 28, 29 NIC) (Ofwat & Govt.). • Climate resilience planning technical standards and codes should be updated working with organisations such as British Standards Institute or the International Standard Organisation - building upon the ISO 22372 Resilient Infrastructure guidelines (Regulators).
Build systemic resilience for critical infrastructure	• Review the ISO 14090/14091 Adaptation to Climate Change guidelines given the importance of interconnections between infrastructure systems to build systemic resilience across the whole infrastructure system if adopted by all (Corporations). • Update drought plans and improve understanding of water customer behavioural for water use, engaging with stakeholders/the Environment Agency on use of water (Water companies). • Adopt a Systems Approach for Water Management in the UK incorporating climate change risks and impacts into investment decision-making in Asset Performance and Deterioration Modelling. In line with Defra recommendations (Corporations).
Measuring Adaptation and Resilience Value	
Innovative cost-benefit measurement	• Explore Innovative methods to measure the value of climate risk reduction and associated co-benefits with quantification of the cost and benefits of adaptation options. This work should leverage guidance from CCC, the Dasgupta review and the Treasury's Green Book example of practices[2] and international work and experience from EC, the OECD and World Bank (HM Treasury).

1 The implementation of Schedule 3 of the Flood and Water Management Act is quite a critical step for implementation of SuDS in England.

2 Treasury's Green Book is guidance issued by HM Treasury on how to appraise policies, programmes and projects. It also provides guidance on the design and use of monitoring and evaluation before, during and after implementation.

Natural Capital Valuation leveraging BNG and TNFD	• Leveraging Biodiversity Net Gain (BNG) for new development and Taskforce for Nature Financial Disclosure (TNFD) for existing built environments, there is a need an opportunity to expand the application of valuation methodologies to capture the value of all Ecosystem Services provided by natural resources, in order to protect and enhance them (Govt.)
Infrastructure value investment leverage	• Methodologies and frameworks, such as PCRAM or CLIMADA, should form part of banks standard lender due diligence processes for climate and infrastructure. This work should be coordinated with the OECD, the Global Infrastructure Hub and the World Bank at international level (Treasury & Regulators, Bank of England (BoE)).

(II) INVESTMENT MODELS AND FINANCIAL INSTRUMENTS	
Investment models to deliver resilient water infrastructure	
Investment / Business models	• As part of the new water sector review, review and adapt the Regulated Asset Based (RAB) model continuing to develop new methods of accessing finance and promoting innovation in meeting their resilience targets in the most cost-effective manner possible to ensure the costs of responding to climate change are minimised (Ofwat). • Remove any barriers to the use of competition when possible replicating models such as the Direct Procurement Model seen in the water sector. Include a requirement in PR24 to assess as part of water companies Business Plans whether any of their large infrastructure projects were suitable to be delivered by DPC (Govt, & OFWAT) • Explore the potential for water credits as a short-term measure to address water scarcity (UK treasury).
Monetising adaptation and resilience benefits through carbon & nature markets	
Adaptation through carbon markets	• Mainstream adaptation in existing market codes integrating measurement of adaptation outcomes into existing and emerging voluntary and compliance nature and carbon market standards and codes (BoE, Regulators). • Streamline regulation and enforcement of private Nature-based Solutions (NbS) markets i.e. 'Voluntary Carbon Markets and Offsetting, consistency is important for ensuring standards of quality without limiting NbS implementation (Regulators).
Resilience standards including nature in real estate	
Resilience standards	• Simplify and clarify definitions for resilience standards in real estate would enhance transparency and boost confidence in the integrity of the market. Resilience standards reduce uncertainty and help to de-risk projects for potential investors while enabling technical certification. (Standard setters) • Undertake green real estate investment and implement resilient and nature-based solutions such as green roofs or sustainable drainage systems in their projects, mirroring the UK Green Building Standards focused on improved energy efficiency within the Future Homes Standard (Real estate developers).

Developing Green Instruments for Adaptation	
Green finance for Adaptation	• Provide guidance to develop metrics for adaptation and resilience from the forthcoming UK Green Taxonomy and the Green Gilt and Green NS&I Bond programmes. This work can leverage International Best Practices on Green Bonds ensuring alignment with the International Capital Market Association (ICMA) Green Loan / Bond Principles and contribute to UNDRR new work on climate resilient classification framework to facilitate investment in climate resilience through capital markets, to be developed by the Climate Bond Initiative (BoE, Govt.). • Issue first dedicated UK Government adaptation bond, supporting local, municipal, and national adaptation projects. This can take form of Sovereign Bonds - Green Gilts - and dedicated national adaptation bonds, such as the Adaptation bond for Resilient infrastructure by the AIIB3 (Govt.). • Revise policy to include tax exemptions for adaptation projects being implemented. One opportunity in this area are 'adaptation bonds' a new asset class modelled after US municipal bonds4 (Govt.). • Further leverage the Green Financing Programme (Green Gilt) will help catalyse further growth of the corporate green bond market in the UK as there is significant demand from investors for liquid green debt securities • Explore sustainability-linked bonds and loans in Real Estate leveraging Biodiversity Net Gain (BNG) regulation (Govt.) • Explore financial products innovation in the UK such as disaster, catastrophe bonds, and parametric insurance products in close cooperation with relevant stakeholders (i.e. EIOPA or Singapore Green Finance Centre)

(III) MOBILISING PRIVATE SECTOR INVESTORS	
Better risk assessment for climate physical risk	
Risk assessment	• Explore and further address physical climate risk challenges developing financial risk metrics (disaster and climate risks) for investors to fully understand their portfolio risks. Engage with international partners such as MDBs and NGFS's new working group on Adaptation financing (Various actors). • Explore further the relationship between climate risks and regulatory capital building on previous work (Bank of England (2021) and Bank of England (2023)) • Engage with Defra to explore the risk of nature loss and degradation and financial risks, leveraging international efforts (DEFRA) • Strengthen physical risk assessment requirements, such as the Climate Biennial Exploratory Scenario by the Bank of England and enlarge the participant pool. (BoE).
Climate risk disclosure as market catalyst	
Climate risk disclosure	• Development of adaptation metrics and guidance within the IFRS Sustainability Disclosure Standards and develop partnerships with the private sector to support delivery. Beyond the recent addition of biodiversity as a target RI theme, consider an ESG + R framework (various actors) • Explore synergies between TCFD and TNFD in the new Green Taxonomy to be published. Beyond the recent addition of biodiversity as a target RI theme, consider an ESG+R framework developing appropriate metrics and indicators for metrics for green bonds (UKIB- MDBS framework UK green taxonomy) (Govt.) • Build upon TCFD and ensure that the TPT standards set expectations for the assessment and disclosure of physical climate risks and adaptation plans across the economy (Govt. & Regulators). • Ensure the meta-standards under development such as Fast Infra or the Blue Dot initiative for infrastructure, are fully aligned and address the user needs across all infrastructure sub-sectors (Standard setters). • Employ impact investing strategies focused on adaptation (Investors).

3 https://www.aiib.org/en/news-events/news/2023/AIIB-Issues-First-Climate-Adaptation-Bond-Targeting-Resilient-Infrastructure.html
4 More about this can be found in Bob Buhr's research at the CCFI here: https://www.imperial.ac.uk/business-school/faculty-research/research-centres/centre-climate-finance-investment/research/adaptation-bonds-lessons-the-us-municipal-bond-market-help-close-the-adaptation-financing-gap/

Adaptation and resilience as an investment theme	
Investment vehicles, long term investors & fiduciary duty	• Exploration of pension fund pooling investment advantages including representation of long-term investors for stakeholder capitalism by the Department for Work and Pensions and Financial Conduct Authority (FCA) (DWP & FCA). • Develop new guidance on fiduciary duty for pension funds in the context of climate change from the Department for Work and Pensions and, in the case of the Local Government Pension Scheme, the Department for Levelling Up, Housing and Communities (DWP & DLHC). • Explore in particular direct investment in non-listed companies and projects (private equity) – active ownership model provides opportunities to work closely with portfolio assets to implement climate initiatives, including adaptation (Govt.).
Blended finance and UK Infrastructure Bank	• Leverage past experience of the Green Investment Bank and international blended finance instruments developed by MDBs targeting international institutional investors (i.e. AIIB and EIB). (UKIB, Treasury and Green Finance Institute) • Review the case for broadening UK Infrastructure scope of activity to include other areas such as improving the UK's natural capital given the potential synergies between climate and nature(UK Treasury) • Include adaptation as a priority in all investors, agency, and government investment strategies (e.g., through targeted concessional finance) and reaffirm it as a part of their remit and a priority (UK IB,BII, Climate Change Committee, Green Finance Institute)

(IV) NATURE, KNOWLEDGE SYSTEMS AND CAPACITY AT LOCAL LEVEL	
Nature positive infrastructure in cities	
Spatial planning in cities integrating NbS, financing adaptation	• Integration of NbS in local spatial land-use plan. Dedicated grant funding could be considered as part of the model to incentivise the use of integrated, nature-based solutions approach in dedicated 'green zones' (CCC 2023) [Gov] • Adopt a systematic approach to addressing adaptation barriers in cities to ensure local inclusion and social sustainability [local authorities] • Improve communication and dialogue on Adaptation Financing best practices among different work streams such as Investor networks and organisations, establishing public-private task forces adopting cross-sector government institutional investment mechanisms, such as the Climate Ready Clyde mechanism5, embed investors' adaptation into the work of these groups - Transition Plan Taskforce workstream • Introduce an overarching policy and one-stop-shop agency for residential development to assist applicants and decision- makers which would bring together all the relevant issues in any given case of an application, including also adaptation impact (GLA). • Ensure coordination between local and national levels on adaptation through a government cross-ministerial joint unit or the establishment of an ad hoc adaptation minister (Gov)
Building with nature in real estate & infrastructure	• Aggregation of nature-based solutions (NbS) for the water sector will make them more investable by providing scale and potentially spread of risks. This could build on the example of the Big Nature Impact Fund (BNIF), which will leverage private sector investment in a range of nature projects in England (Developers and Investors) • Leverage TNFD disclosures in real estate likely to increase the focus on the biodiversity impacts of existing assets and portfolios, whereas BNG legislation focuses on new developments [Gov, Investors] • In Infrastructure sectors such as transport, water and flood risk management, leverage biodiversity net gain by requiring sectors to take a strategic approach to enhancing natural capital across their assets [Gov, Investors]

5 Climate Ready Clyde – see more here: http://climatereadyclyde.org.uk/wp-content/uploads/2021/09/10-Annex-3-Resource-Mobilisation-Plan.pdf

Local green finance & Place-based investment models for adaptation	
	• Local authorities to engage with businesses and investors for place-based investment models to be developed, exploring crowdfunding options and climate bonds at local level and the development of a Municipal Green Bond market in the UK. [Greater London Authority] • Strengthen local planning and local government planning regimes for adaptation and resilience by 2030. Reintroduce a statutory duty to adapt to climate change for the public sector in England. [HM Treasury] • Create an Urban Taskforce for Greater London to scope bankable projects, match-make investors, and set up the financing mechanisms. [HM Treasury] • Follow the European Union's Horizon Europe project to get inspiration for developing strategies and contribute to knowledge sharing for the GLA. [UK Treasury] • Supporting local capability and authorisation and regulation of financial products is an important role respectively for UKIB in and for the Financial Conduct Authority [UK Infrastructure Bank & FCA]
AI, Data analytics and Information systems for Climate Adaptation Financing	
	• Build knowledge systems that enable investors, contractors and policymakers to access climate data and information on infrastructure resilience and NbS. Regulators must implement a system for cross-sector stress testing that addresses interdependencies and the risk of cascade failures. (See Recommendation 30 from NIC) [Government and Investors] • Collect Data and establish a repository on Cost of Capital for Adaptation projects at Imperial College building on the Observatory of Cost of Capital initiative by IEA, ETH Zurich WEF and Imperial College (various actors) • AI and Climate analytics: In collaboration with the UK CGFI embrace the possibilities from AI, big data and disruptive tech, encouraging the sector to use more open data DIGITAL TWINS [Academia and Industry] • Promote and support the use of Risk Data Hub to harmonise the recording and collection of comprehensive and granular climate-related risk and losses data, and promote national level public-private partnerships to collect and share such data (Government) • Explore with the industry the best ways to improve the collection of uniform and comprehensive insured loss data (connect to similar exercise at European level from EIOPA) (BoE) • Ensure that the new UKRI climate change adaptation hub can coordinate new transdisciplinary research projects launched in the UK and support international level engaging EU with Horizon research and funding (DEFRA)

1. Key Findings and Policy Actions Areas

Adaptation & Resilience Investment Gap. Globally, there is a large and chronic underinvestment in adaptation, which is lagging behind other climate areas such as mitigation, nature, and biodiversity. In 2021, only 9% of global urban climate finance flowed to adaptation, compared to mitigation (Knight & Negreiros, 2022 and CPI, 2021). In 2023, UNEP estimated adaptation needs at US$187-359 billion per year (UNEP, 2024). This suggests the adaptation finance gap is significant and more capital needs to be channelled towards adaptation. Therefore, we expect adaptation markets to mature and evolve over the next decade, which will require overcoming several challenges.

Cities are highly vulnerable to climate change. Without substantial investments in adaptation, urban areas, their economies, infrastructure, and inhabitants face significant vulnerability to climate-induced extreme events, resulting in substantial costs. The heavy rainfalls in the UK in July 2021 and the heatwaves of summer 2022 resulted not only in serious infrastructure damage but also social and economic costs. Climate change will impact London both in the short term and long term, which highlights the necessity of adaptation now.

The current approach to adaptation investment and financing in the UK is not working. This is related to a wider failure to manage at the same time significant challenges from climate change, biodiversity decline, population growth and aging infrastructure. According to the London Climate Resilient Review in 2024 and a recent evaluation of the Third National Adaptation Programme (NAP3) published in July 2023, governance, investment and monitoring issues are limiting an adequate response to climate risks in the UK (CCC, 2024). In particular, the evaluation highlighted as major challenges the lack of funding for adaptation and the poor understanding of private sector adaptation. While the UK might have lost its place as a leader in climate adaptation, there is much that can be drawn from international best practices.

Reaching net zero and increasing resilience, requires important investments that must be climate proofed. The UK National Infrastructure Commission's analysis suggests that overall investment to deliver net zero and increase resilience must go from £55 billion per year over the last decade to approx. £70 to 80 billion per year in the 2030s (NIC, 2030). This investment include opportunities for investment in energy security and reaching net zero, supporting growth across all regions and improving resilience and the environment. Given the magnitude of the challenge, it is essential to bridge the adaptation finance gap through innovative approaches that will effectively mobilise additional financial resources.

The UK is at a critical juncture where new physical infrastructure is needed to adapt to a changing climate. In the water sector, population growth and drought resilience necessitate a significant new programme of investment in infrastructure such as reservoirs and interconnectors, as well as improvements in water efficiency. The draft Water Resource Management Plans underscore this urgency, indicating the need for nine new large reservoirs, two reservoir enlargements, three large intercompany transfers, 11 water recycling schemes, and nine new desalination plants (NIC, 2023).

Private sector financing in adaptation and resilience in the UK is still limited. Adaptation that results in widely distributed (public) climate risk reduction benefits for many beneficiaries (floods, health, nature restoration and transport infrastructure) requires public financing and funding. As shown in Part I of this analysis, in the few case studies where adaptation and resilience are the primary considerations requiring dedicated investment, the capital-intensive nature of infrastructure in property and water sector necessitates substantial additional investment for targeted projects.

Climate resilience is often a secondary driver for investors. Most case studies show substantial adaptation co-benefits, usually delivered as secondary objectives and integral to mitigation and nature objectives. While the financial benefits for adaption investment are low in **most of the case studies analysed**, a few projects demonstrated the financial viability of blending project returns with nature-based solutions providing adaptation benefits. Realising benefits face several barriers including high costs and lack of replicability and scale to attract financial investment, complex coordination and multiple actors and differing perceptions about who should pay (public or private).

The case studies have shown innovation in investment models and financial instruments associated with adaptation and resilience across sectors. Encouragingly, there is potential for innovative financing mechanisms, but significant barriers exist across the financial ecosystem. Addressing these barriers will require substantial Government interventions to mature and transform the market. Investment models and

financial instruments present different maturities with several solutions needing further development and support. to be replicated at scale. Major implementation challenges, such as investability and affordability need to be taken into consideration for ultimate viability.

Institutional investors with a long-term horizon are increasingly engaging in adaptation and resilience. Adaptation and resilient investments are already part of investors' portfolios. These include more mature assets such as infrastructure and timber or developing assets such as nature-based solutions or information systems and climate analytics. While there is potential to mobilise further pension savings capital, the physical risk is currently under-estimated by investors. Disclosure frameworks such as TCFD are not major drivers for investment in adaptation options, despite being an important consideration for institutional investors and large corporates.

London should aim to be a global green finance centre for adaptation and resilience. As seen in Urban Adaptation Financing (Part II), despite its reputation as a green finance centre, London relies heavily on public funds, highlighting the need for greater involvement of private capital. The policy and financing ecosystem in greater London is fragmented, with multiple layers of policies and funding sources not aggregated. While planning and strategic initiatives have been present longer, financing initiatives have only started to emerge more recently. The London housing crisis is an opportunity to rethink urban planning while opening new opportunities for green infrastructure and adaptation.

Nexus Climate & Nature. The analysis also underscores the interconnectedness of adaptation with other policy priorities and areas of policy actions such as nature restoration, net zero, infrastructure development and health. In particular, lessons from nature and biodiversity markets can inform approaches to adaptation financing, from natural capital accounting for co-benefits valuation to nature markets, to the use of nature-based solutions at the urban level. As the case studies illustrate, whilst private investments in nature are possible, scaling and replicating them requires concerted efforts.

Below we highlight the main policy areas for action considered in this report.

(I) MARKET CREATION: A MARKET THAT VALUES ADAPTATION AND RESILIENCE

Investors lack visibility on existing and prospective opportunities in adaptation and resilience. Investors are often not considering adaptation measures when investing in the transition, missing potential investment opportunities. It is possible to combine mitigation-based revenue streams with longer-term adaptation outcomes, for example, there are opportunities to ensure new investments are climate resilient for the UK's planned zero-carbon electricity grid, as well as opportunities to invest in EV charging (EV charging with a national operator) or Solar PV (the large roof space of the buildings). Based also on future transition investment plans, there is a need to provide information on likely adaptation financing needs by type of sector and risk, including a role for public and private finances.

Security and critical infrastructure considerations are opening opportunities to invest in resilience through AI and Fintech solutions, asset maintenance and renewals. As most infrastructure assets operating in 2055 in the UK have already been built (NIC, 2023), better asset maintenance and renewal are critical to achieving more resilient infrastructure. This includes building systemic resilience in water management - accounting for interdependencies and cascading failures. There are significant opportunities to invest in adaptation solutions and nature financing, leveraging AI and big data, in long-term adaptive planning, data management, restoration and protection of the environment, and use of nature-based solutions.

Being clear on the range of metrics and information, will allow to quantify benefits and maximise revenue streams. However, standards for defining, measuring and monetising adaptation benefits are needed, with the Government playing an essential role in ensuring that these are aligned with national frameworks and targets for adaptation and climate resilience. If the Government does not set clear service standards by 2030, around £400 billion in future investment in infrastructure may not be climate-proofed or optimised for resilience (NIC, 2023). The National Infrastructure Commission has recommended in a recent report that government should publish resilience standards for the digital and telecoms, energy, transport, and water sectors by the end of 2025 (NIC 2024).

Adaptation, often overlooked in financial valuation, requires the establishment of a market for its outcomes. Conventional cost-benefit analysis for adaptation often fails to identify the value creation for adaptation and resilience. The CCRA3 Valuation study presenting available evidence for cost and benefits

analysis highlighted major issues including methodological and data problems, high site- and contextspecificity, long periods, high levels of uncertainty. More work is needed to understand better the value of investing in natural capital and infrastructure for adaptation.

(II) INVESTMENT MODELS AND FINANCIAL INSTRUMENTS

Adaptation measures in the water sector must address short-term urgency and long-term needs. In the water sector, addressing the critical long-term priority of water security necessitates government intervention to implement significant water supply infrastructure, such as reservoirs, innovative water management techniques in agriculture and the implementation of nature-based solutions.The adoption of investment models for the delivery of large projects in the water sector, include the regulated asset-based (RAB) model, the Direct Procurement for Customers (DPC) and the Specified Infrastructure Projects Regulations model (SIPR). At the same time, to meet the immediate need for solutions beyond water efficiency and reuse, the introduction of a 'water credits system' that capitalises on developing a carbon and nature market can serve as an additional avenue for financing.

Nature and carbon markets offer revenues streams to investors, monetising adaptation and resilience benefits. Nature markets offer land managers the opportunity to receive compensation for implementing conservation and restoration initiatives that benefit resilience and the environment. By leveraging their land for environmental projects, land managers can generate revenue by selling these ecological services in the form of credits or units to various stakeholders. However, new legislation has an additional planning burden and cost to development for under-resourced local administration making it often difficult to implement.

Urban green space, adaptation, and property value. Buildings associated with open spaces can add to the aesthetic setting of an area, increasing attractiveness to residents and businesses and increasing the property value[6]. Beyond recreation and physical health benefits, they can reduce climate hazards, such as flood management. The property premium will reflect the scale of the benefits and other spatial factors, such as proximity, population density and availability of substitutes. As shown in the case studies Craigleith Retail Park and Canary Wharf Real Estate, the increase in property value can be captured through monetisation. A major challenge is the lack of data or poor quality, compounded by unclear definitions and numerous reporting frameworks. Better data and frameworks are needed for transparency and comparability.

The findings underscore the urgent need to facilitate the development of new financing instruments for adaptation measures and projects. While sustainability-linked bonds and loans in resilient buildings and water efficiency are rapidly growing, the inclusion of climate resilience is still limited and only tiny proportion of green bonds are currently used for adaptation and resilience financing. A revolving fund for wastewater treatment and stormwater drainage improvements cannot only monetise savings but also increase property values and rental yields. Crowdfunding at municipal and local levels can address constraints due to lacking resources and financing.

Affordability vs Investability. Viable models need to consider the investability of spending programmes, including the financial sustainability of companies and investors and customers' affordability capability. In fact, companies and asset owners will often need to borrow to finance these investments, ensuring they are financially sustainable. Recent research shows that constrained households have weaker incentives to adapt to climate change due to a focus on consumption in the present, exacerbating wealth inequality with spillover effects to future generations (Van der Straten, Y. 2023). Ultimately, investment models providing resilience benefits must leverage innovation, ensuring a low whole-life cost for the projects.

Role of regulators is critical in driving private investors to adapt. The role of governments' changes for privately owned assets, such as real estate, or publicly owned infrastructure regulated through concessions such as Private-Public Partnerships or Regulated Asset-Based systems. Regulators in infrastructure sectors, such as Ofwat for water and Ofgem for energy, must facilitate and incentivise resilient investment. Even in real estate, there is a strong need for policy action to signal and regulate climate and nature benefits. National and local landscape management and regulation are central in developing carbon markets and nature restoration projects supporting adaptation actions.

6 Case studies of five open space sites in the London Borough of Barnet suggested property value premiums of 10-15% to over 2000 residential properties and of 3% to over 50 commercial properties nearby (Eftec, 2017).

(III) MOBILISING PRIVATE SECTOR INVESTORS

Climate physical risk and nature deterioration are currently under-estimated, and investors may be subject to hidden contingent liabilities with implications on an investor's fiduciary role and financial stability. In private markets, recent research from EDHEC found that a disorderly climate transition represents a risk of at least USD 600 billion for investors in infrastructure, i.e. about ¼ of the current market value of all privately invested infrastructure in 27 countries (Amenc et al., 2023). The finance sector will need to better incorporate adaptation into their operations to ensure that viable adaptation projects do not fail due to a lack of finance.

New operational frameworks (ESG + R), including resilience outcomes, are required for climate-related financial disclosures. Increased transparency and visibility of material risks can raise awareness of climate risks and adaptation and drive investment. Notably, the Taskforce for Climate-related Financial Disclosures (TCFD) framework is now integrated into the UK's Sustainability Disclosure Requirements (SDR) Framework, impacting reporting cycles for large and listed companies. For nature and biodiversity finance, the Taskforce on Nature-related Financial Disclosures (TNFD) published its disclosure recommendations in September 2023.

Pension funds are looking for diversification in the private markets. The case studies show that investors focus on investments with asset backing, contractually fixed or otherwise secure cash flows (with some inflation linking), and limited economic or operating exposure. Different investment vehicles are used to secure the adaptation investment, targeting risk-adjusted returns of less than 10% IRR net of fees in closed-ended private market funds. Co-investment opportunities offer scale advantages with cost reduction, lower fees, and expertise in funds and secondary products. However, in many adaptation investments, the benefits and potential revenues that can be generated are realised over a long period, sometimes several decades. There is also a lack of co-investment vehicles designed to encourage institutional investors to invest in adaptation.

Leveraging the UK Infrastructure Bank (now National Wealth Fund) to de-risk projects and attract private investment for adaptation action. Beyond direct public expenditure, public financing (the upfront capital) can also be used to mobilise private sector capital by blending and de-risking private investment. This could be in the form of subsidies for projects and programmes or the provision of guarantees to the private sector. However, securing additional public financing to incentivise private sector involvement may lead to fiscal space challenges and could divert attention and resources away from other important political priorities. Therefore, it's crucial to contemplate the catalytic effect of the capital and employ public resources more efficiently. The UK Infrastructure Bank (UKIB), launched in 2021 and now transformed into the new National Wealth Fund could have an essential role[7].

Several proposals and initiatives have been put forward to mobilise pension savings pools. A recent study from the London School of Economics and Political Science (LSE) estimated that based on the £4.6 trillion of current insurance and pension fund assets in the UK, blended finance funds proposals together could potentially unlock £5 billion in private investment for public policy priorities at the time of the funds' launch, and at least £50 billion in the next five to 10 years (LSE 2023). In its Levelling Up white paper, the Government set out its ambition for Local Government Pension Scheme (LGPS) funds to invest up to 5% of their assets (£18.45 billion) in projects that support local areas which could target climate resilience (UK Government, 2022).

(IV) NATURE, KNOWLEDGE SYSTEMS AND CAPACITY AT LOCAL LEVEL

Investing in nature-positive city infrastructure remains crucial to addressing biodiversity loss and climate change impacts. A major conclusion from our analysis is that a close nexus of adaptation with nature exists, and much can be learned from nature and biodiversity markets (Casey & Connor, 2023). Urban vegetation, including street trees, green roofs, green walls in urban green spaces, and green buildings, can be a crucial adaptation measure for heat and air pollution risks and enhance biodiversity. Bioswales, rain gardens, and retention ponds can improve flood management and soil quality. Retrofitting the existing social housing stock will cost an estimated £104 billion across the UK (Meanock, 2022), while in London alone, the funding requirement for providing new social housing is forecast to be £22.2 billion between 2023–24 and 2027–28, or £4.9billion a year (Savills and GLA, 2022).

7 The UK Infrastructure Bank has become the National Wealth Fund, with a broader remit, more capital and a greater capacity for risk.

There is an opportunity here to embed resilience in these social housing programs. However, there is evidence that the multiplicity of policies in the London Plan makes the application process expensive and time-consuming, especially for small and medium enterprises.

Urban adaptation financing highlights synergies and trade-offs between social and environmental sustainability and the importance of spatial planning. To improve urban adaptation and preserve biodiversity, we need changes in human behaviour driven by holistic urban planning and incentives highlighting sector interconnections (Imperial, 2023). Finance barriers interact with economic and socioeconomic conflicts and must be considered within a spatial and integrated perspective (Hinkel et al., 2018). Social sustainability is critical to the transition in the real estate sector. Private investment for adaptation can lead to 'gentrification' whereby low-income populations are relocated from urban centres and safer settlements. On the other hand, socially sustainable developments can also enhance 'placemaking' to strengthen the connection between people and place.

Capability and financing at a local level are significant barriers to adaptation action. At the urban level, there have been numerous attempts to innovate in climate finance, such as mobilising community and cooperative forms of finance or crowdfunding (IPCC, 2023; De Broeck, 2018). As seen in the case studies, there are opportunities at the local level to extend the Green Gilts and Bonds offered by the government and National Savings and Investment (N&SI) to allow investors and retail savers to contribute to the supply of capital for adaptation. UKIB has a significant role in supporting local capability in addition to financing. It can contribute with dedicated lending offerings for climate projects or borrow from markets through Green and Sustainable Bonds. Developing a local municipal bond market in the UK requires setting local adaptation plans and targets.

Artificial intelligence technology and 'big data' can help financial actors manage hazard risks more effectively while offering investment opportunities. The growing availability of high-resolution, publicly accessible global data enables the development of global risk models, even in countries where official data is difficult to access. Smart city infrastructure, such as in Singapore - as seen in Part II of this policy brief - offers the opportunity to integrate existing data collection and monitoring systems at the local, subnational, and national levels. Technologies such as remote sensing and smart sensors can be leveraged to get regularly updated and automated information processes, thus enabling regular monitoring of the status of infrastructure systems and their resilience.

2. Creation of a Market to Value Adaptation and Resilience

2.1. Existing Opportunities to Invest in Adaptation and Resilience

Building resilience and leveraging planned investment for Transition Plans

Reaching net zero and achieving other pressing public policy priorities, such as the provision of quality affordable housing, will also open new opportunities. Retrofitting the existing social housing stock will cost an estimated £104 billion (Meanock, 2022), while in London alone, the funding requirement for providing new social housing is forecast to be £22.2 billion between 2023–24 and 2027–28, or £4.9billion a year (Savills and GLA, 2022) There is an opportunity here to embed resilience in these social housing programs.

Infrastructure regulators, hold a pivotal role in driving resilience investment. They have the power to mandate investment that aligns with long-term resilience needs. The 2024 water price review (PR24) will significantly shape the delivery of critical infrastructure and investment for 2025-30 and beyond. In the previous review (PR19), Ofwat, the water regulator, allowed £13 billion of expenditure on resilience, setting performance commitments related to improving resilience in the sector, with a specific focus on supply interruptions, sewer flooding, and asset health.

Corporates too have a crucial role to play in addressing the challenges of climate change. Companies are expected to use scenario planning and other techniques to mitigate future uncertainty in their strategies[8]. From PR24 onwards, Ofwat is asking companies to submit long term delivery strategies alongside their 5-year business plans. This proactive approach will help companies better address the challenges and uncertainties of climate change, aligning their strategies with the long-term resilience needs of the water sector, as outlined in the Representative Concentration Pathways (RCPs) adopted by the

8 Ofwat, 'Long-term delivery strategies and common reference scenarios', November 2021.

Intergovernmental Panel on Climate Change (IPCC) in its 6th assessment report. Nature-based Solutions can also enable companies - where applicable - to better manage the risks from climate change and contribute significantly to water infrastructure resilience.

Recommendation to Government and Investors: Take an integrated approach to mitigation, adaptation and nature in both policy and investment, leveraging planned investment flows for Transition Plans - to be resilient to future climate conditions or future social housing expenditure aligned with resilience goals needed in London.

Building on CCRA3, CCC/CCRA4 will estimate current government adaptation spending and provide a detailed assessment of adaptation costs for England/UK. This would outline adaptation financing needs for public and private sectors, highlighting risks and opportunities. Integrated schemes could address climate change mitigation and adaptation together to optimise benefits and revenue.

Recommendation to Ofwat: Allow expenditure of the 2024 water price review (PR24) on resilience and make public the performance commitments from PR19 related to operational resilience improvement.

Recommendation to Corporates and Ofwat: Encourage companies in the upcoming PR24 to shift their focus towards the long term and increase private sectors use of nature-based solutions. By requiring the submission of long-term delivery strategies alongside their 5-year business plans, water companies can effectively prepare for the challenges and uncertainties of climate change.

Private sector's use of **nature-based solutions** will enable companies to better manage the risks from climate change and contribute significantly to water infrastructure resilience.

2.2 Mainstreaming Adaptation & Climate Proofing Investments

Asset management & planning – resilience

Asset management practice is crucial for long term resilience of infrastructure networks to allow better understanding and preparation of climate risks to assets. For the water sector, climate change threatens to accelerate the deterioration and, thus, the ability of assets to deliver water supply, drainage, water treatment and protect against flooding. In Ofwat's Asset Management Maturity Assessment, several recommendations are outlined (Ofwat 2021).

Recommendation to the Government: Should prioritise maintenance and renewal of the existing infrastructure network (i.e. energy, water and transport), ensuring resilience to climate change impacts.

Recommendation to Regulators: Monitor companies' asset health and operational resilience and incentivise approaches to long-term asset planning. Reporting and publication are required, including information on asset management maturity.

Recommendation to Infrastructure Companies: Improve companies' approaches to long term planning and risk management uncertainty through better alignment between short- and long-term objectives leveraging data and information management (and allowing data exchange).

Resilience planning technical standards

Regulations may specify detailed technical standards for quality, resilience, and contractual outcomes related to service duration and minimum requirements (OECD 2021). Asset and maintenance standards allow to hold contractors accountable for project and professional specifications and can be embedded in contractual provisions improving maintenance delivery. The National Infrastructure Commission has recommended in a recent report that government should publish resilience standards for the digital and telecoms, energy, transport, and water sectors by the end of 2025 (NIC 2024).

Among major international standards for quality infrastructure are the British Standards Institution's (BSI) Publicly Available Specification (PAS 55), the International Standards Organisation 55000 (ISO 55000), and two major international standardisation organisations: the European Committee for Standardisation (CEN, Centre Européen de Normalisation) and (WEF 2014 and OECD, 2018). For example, Australian

standards for pavements, road barriers, and street lighting support decision-making by measuring the value of road maintenance and renewal work, as well as maintenance and performance outcomes (OECD 2021).

Appropriate resilience standards must be integrated at the project planning and design stage, both in capital expenditure (CAPEX) and operating expenditure (OPEX). Integrating financial risk metrics into asset design enables more predictable cash flows, improved credit quality simulations, and a more efficient allocation of costs across the whole asset lifecycle (CDRI 2023).

Recommendation to the Government: Require regulators in their undergoing price determination to ensure regulatory settlements are consistent with operators meeting stringent resilience standards in the short and longer term (See Recommendation 28, 29 NIC).

Recommendation to standard setters: Update climate resilience planning technical standards and codes by collaborating with standard setters as British Standards Institute or the International Standard Organization (ISO) developing relevant standards (ISO 22372 Resilient Infrastructure —Guidelines).

Build systemic resilience for critical infrastructure - accounting for interdependencies and cascading failures

There is a need to develop a greater understanding of the impact of climate change and extreme weather events on the performance of infrastructure and systems. Large adaptation interventions due to climate risks can have benefits and costs across a range of factors with major interdependencies across energy, water, transport, and information and communication technology (ICT). Risks to critical infrastructure have been identified and experienced in many areas over the past few years due to COVID-19 or cyber-security threats. There is a need to analyse the vulnerabilities of critical infrastructure (e.g., power grids, transportation, water supply) to extreme weather events (Abdelaziz et al., 2024). This analysis should identify regional vulnerabilities, estimate potential economic impacts of disruptions, and inform adaptation strategies to enhance infrastructure resilience (Leach et al., 2022).

Water security as a driver of investment. Several case studies contribute to climate adaptation by dealing with water scarcity, an issue increasingly threatening the UK and directly associated with other sectors, such as sustainable agriculture. Water availability is affected by agricultural use, as seen in the case studies Part I, with one case covering a project where farming fertilisers impact the pollution of rivers in terms of phosphate and nitrate concentration. Changing working habits and growing population are other factors affecting water use with higher temperatures. However, water management, financing, and planning in the UK are not adequately integrated.

Interdependencies and the risk of cascade failures impact the resilience of assets. Proper asset management of infrastructure assets ensuring systems are resilient to climate change and future risks should include knowledge components such as national infrastructure registries or audits of national risk information systems (for example, a digital national risk atlas) (CDRI,2023). Infrastructure operators will need to assess the resilience of their own systems and interdependency risks with other systems. Valuable tools such as the Connected Places Catapult's climate resilience demonstrator can support this.

Recommendation to Infrastructure Companies: review the new ISO 14090/14091 Adaptation to Climate Change guidelines reports, given the importance of interconnections between infrastructure systems. This is a beneficial action identified by the independent advice report for the CCRA3, which will help build systemic resilience across the whole infrastructure system

Recommendation to Water Companies: Update drought plans and improve understanding of water customer behavioural for water use, engaging with stakeholders on the use of water, the Environment Agency on catchment abstractors - such as the Horticultural Society and National Farmers Union.

Recommendation to Water Companies Adopt a Systems Approach for Water Management in the UK incorporating climate change risks and impacts into investment decision-making in Asset Performance and Deterioration Modelling. In line with Defra recommendations, review operational model for the next price review (PR24) to include wider environmental factors and other factors such as supply chain failures

Recommendation to Government and Investors: Build knowledge systems that enable investors, contractors and policymakers to access climate data and information on infrastructure resilience and NbS. Regulators must implement a system for cross-sector stress testing that addresses interdependencies and the risk of cascade failures. (See Recommendation 30 from NIC: By the end of 2025, the Met Office, infrastructure operators and appropriate regulators should work together to develop an accessible interface for asset owners to use relevant climate data).

2.3 Measuring Adaptation and Resilience Value

Adaptation, often overlooked in financial valuation, requires the establishment of a market for its outcomes. The benefits of ecosystem services, which are contingent on the adaptation areas and sectors, can be effectively measured through 'Natural Capital Accounting.' This approach takes into account the stock of natural capital that generates the flow of these services. While financial benefits from adaptation projects are a key driver for private sector investment, it's essential to address methodological and data issues, such as site- and context-specificity, long periods, and high levels of uncertainty, to ensure the accuracy of these measurements.

Innovative Cost Benefit Analysis

Mapping and quantification of benefits and beneficiaries is necessary to inform the identification of potential revenue streams and relevant financiers. Adaptation often leads to important co-benefits, reducing potential future losses from climate change, generating direct economic gains and leading to social or environmental benefits.

The European Commission is active in looking to provide ex-ante project assessment tools to better identify co-benefits and positive impacts on the economy of adaptation and prevention projects (EC 2023). In 2021 and 2024 the EC funded World Bank studies on the Economics of Disaster Prevention and Preparedness in Europe, focusing on the cost of adaptation[9].

Recommendation to HM Treasury: Explore innovative methods to measure the value of climate risk reduction and associated co-benefits with **quantification of the cost and benefits of adaptation** options. This work should leverage guidance from CCC, the Dasgupta review, the HM Treasury's Green Book example of practices[10] and international work and experience from OECD, EC and World Bank.

Natural capital valuation in real estate: leveraging the Biodiversity Framework & TNFD

Investing in natural features based on their economic value is an important dimension of green finance. Accounting frameworks can help appraise the value of the natural environment. This is important to understand the economic value and inform planning management and investment decisions for public and private sector (CCRA 3).

9 Research from the World Bank and European Commission offers evidence and tools to help countries take a more strategic approach to boost their climate resilience. https://documents1.worldbank.org/curated/en/099050224072033005/pdf/P17907015a302401f1b7e51fc14ed9b73ef.pdf.

10 HM Treasury's Green Book is guidance on how to appraise and monitor policies, programmes and projects.

However, environmental accounting methodologies and their use in cost-benefit analyses are still not standardised. The UK Office for National Statistics, the WAVES programme led by the World Bank and the UN System of Environmental Economic Accounting are working on methodologies to report on natural capital accounts. Corporate Natural Capital Accounting uses a balance sheet format for documenting natural capital assets and liabilities also at urban level (i.e. London Borough of Barnet in 2017).

TNFD disclosures are likely to increase the focus on the biodiversity impacts of existing assets and portfolios, whereas BNG legislation focuses on new developments. Land managers leveraging BNG guidance and knowledge will be able to support future management of natural assets. Biodiversity Frameworks developed by real estate developers should be associated with emerging drivers including Taskforce for Nature-related Financial Disclosures linked reporting.

Recommendation: Leveraging BNG for new development and TNFD for existing built environments, there is an opportunity to expand the application of valuation methodologies to capture the value of all Ecosystem Services provided by natural resources, in order to protect and enhance them.

Infrastructure value investing: PCRAM, CLIMADA and Global Infrastructure Hub

The risk profile of investments impacted by climate change remains a critical barrier to investment. Infrastructure has a long lifetime and is exposed to large future climate change impacts resulting in impacts on assets (damage or failure). At the same time, there is a risk of long-term emissions being locked in. In addition to the direct risk of damage and disruption of individual assets, there is a risk of indirect or cascading risks associated with infrastructure, especially critical infrastructure (CCRA 3).

There are a number of methodologies and tools that facilitate the identification of the resilience value. For example, the CCRI Physical Climate Risks Assessment Methodology (PCRAM) determines the baseline climate resilience level of an asset and undertakes a cost-benefit analysis of potential resilience options (Chavarot et al., 2021). This is a decision-making support tool that integrates climate vulnerability and risk assessment with economic and sustainability impact studies to determine a portfolio of optimal adaptation measures for diverse climate risks. It is supported by the quantitative modelling tool CLIMADA.

Recommendation to the UK Government: Support the Coalition on Climate Resilient Investment (CCRI) to develop tools to more efficiently and effectively price physical climate risk to reduce the cost of capital. Methodologies and frameworks, such as PCRAM (developed by CCRI) or CLIMADA, could form part of banks' standard lender due diligence processes for climate and infrastructure. This work should be coordinated with the Global Infrastructure Hub and the World Bank at the international level.

3. Delivering Adaptation: Investment Models and Financial Instruments

3.1 Innovation in Water Revenue Models

The regulated asset-based (RAB) model, considering regulatory cycle adjustment to include adaptation spending, could be used for more infrastructure adaptation projects involving multiple parties across the UK. The Tideway model (a GBP 5 billion London wastewater investment is financed, owned and managed separately from Thames Water), a variant of the RAB model, enables investors to share some of the project's construction and operating risks with consumers, lowering the cost of capital and resulting in risk-sharing between investors and consumers. However, the current RAB regulatory cycle of 5 years does not prioritise capital investment and longer-term adaptation projects that will benefit future water users. Given the long-term nature of the Havant Thicket Storage Reservoir, Ofwat considered that a separate ten-year price control better aligned the cost and risk sharing arrangements between customers and shareholders of both Portsmouth Water and Southern Water.

Water companies can achieve significant benefits for customers through competition. Procurement of major new infrastructure projects opens up competition to provide finance and innovation for new infrastructure, lowering the cost for consumers. In the water sector there are two competitive delivery models for the delivery of large infrastructure projects, the Direct Procurement for Customers (DPC) used for the Thicket reservoir case study[11] and the Specified Infrastructure Projects Regulations model (SIPR), which

11 The DPC model for Thicket reservoir was considered against a Design and Build (D&B) model. Among factors to consider for DPC

was used to deliver the Thames Tideway Tunnel. These models require companies to put a project out for competitive tender for delivery by a third-party infrastructure provider who will design, build, finance, and in some circumstances operate and/or maintain the relevant infrastructure. The key difference between DPC and SIPR is that under SIPR, Ofwat can licence and directly regulate the infrastructure provider. In PR24, delivery through DPC will apply by default for all projects above a size threshold of £200 million.

Water credits mechanisms are tested in the UK. In water management in Cambridge, to redress the water supply shortfall the government is focusing on more efficient water use and water credits mechanism, while water utility companies are building the planned reservoirs (See next section). This commitment is supported by substantial investment in initiatives aimed at counterbalancing the augmented demand for water in the region, which is achieved through the installation of water-efficient devices in existing structures and the implementation of large-scale water supply infrastructure projects such as the Grafham transfer and Fens Reservoir (DEFRA 2024).

Recommendation to UK Treasury and Ofwat: In the review of the water sector launched by the UK government in October 2024, ensure the RAB model viability and adaptation use, continue to develop other new methods of accessing finance and promoting innovation in meeting their resilience targets in the most cost-effective manner possible. This implies understanding the use of competition in infrastructure networks, replicating models such as the Direct Procurement Model seen in the water sector. Include a requirement in PR24 to assess - as part of water companies business plans - whether any of their large infrastructure projects are suitable to be delivered by DPC. The review must look beyond the water industry to include land and water management in both urban and rural areas.

3.2 Carbon & Nature Markets for Adaptation and Resilience

Nature markets, including carbon sequestration and flood alleviation, can be mandatory or voluntary (see Figure 1). They can create a market in biodiversity units or nutrient credits, attract private landholders to conserve the land and provide funding sources for local authorities[12]. The Aviva-Glen Dye Case study seen in Part I of this analysis is a nature-based adaptation project generating carbon credits. The adaptation benefits are delivered through ecosystem restoration that, in turn, reduces water scarcity through on-site water management, and control of flood risk in the area.

adoption are Operation and Maintenance (O&M) project costs compared to construction costs, the potential for DPC-driven innovation, the project's cost to customers, include financing costs and equity hurdle rates, size and length of the project, and operational complexities. According to Portsmouth Water Business plans 2020- 2025 the two models presented the following characteristics: Design and Build (D&B) Model Initial outline design carried out by Portsmouth Water, detailed design and construction carried out by third-party contractor. The contract itself for the reservoir would be let on a target cost basis with a pain/gain share mechanism. DPC Model Outline design carried out by Portsmouth Water, then financing, detailed design, construction and maintenance carried out by a contractor (the Competitively Appointed Provider or CAP) on a fixed price basis (save for specifically agreed aspects).

12 The UK Government has recently guided land managers, encouraging them to combine biodiversity units and nutrient credits. This guidance allows them to sell these alongside other environmental payments, thereby maximizing their environmental impact. Biodiversity units are calculated using the size of the habitat, its quality, and location. https://www.gov.uk/guidance/combiningenvironmental-payments-biodiversity-net-gain-bng-and-.

Figure 1: Revenue sources for nature and adaptation

Types of revenues	Examples	Summary
Compliance markets – Biodiversity Net Gain	Salterswood Farm, Cheshire WT	10% or more gain on biodiversity as a result of any development. Mandated **in England** by 2021 Environment Act; comes into full force in January 2024.
Compliance markets – Nutrient Neutrality	Little Duxmoor, Hampshire and Isle of Wight Wildlife Trust; Eldon Moor, Durham Wildlife Trust	Mandated through European Court in relation to gross pollution of SACs/SPAs. Three schemes underway **in England:** local planning authority led; developer led; and Natural England led.
Voluntary markets – voluntary carbon market	The Wildlife Trusts' temperate rainforest project with Aviva	Credits based on removing from the atmosphere or reducing emissions to the atmosphere of greenhouse gases expressed as tonnes of carbon-equivalent (where 1 tonne = 1 carbon credit). In the UK verified through Woodland Carbon Code and Peatland Code.
Voluntary markets – conservation credits	No UK examples as yet but being developed by Nattergal Estates and through Operation Wallacea but internationally	Similar to BNG but offered as a voluntary credit rather than as a compliance credit. Operation Wallacea have created a pan-global credit scheme that is being sold to international corporates. Could be encouraged by moves towards nature based financial (TNFD – the task force for nature based financial disclosure)
Other ecosystem service sales	Yorkshire peatland restoration for water quality benefits	This could include traditional revenues such as produce sales or newer services such as nature tourism but might also include sales relating to improving water quality or flood protection.

Source Dr. Rob Stoneman, Director of Landscape Recovery, The Wildlife Trusts, Seminar 19th March 2024 Squire Patton Boggs. https://www.youtube.com/watch?v=M3sFuJGOBzU.

Compliance markets are supported by Biodiversity Net Gain (BNG) and Nutrient Neutrality. BNG is a new approach to planning/land management aiming to leave biodiversity in a better state than before development. This translates into a mandatory requirement for a BNG of plus of 10% or more gain on biodiversity. This has been acknowledged in national planning policy and has been mandatory since February 2024[13]. Nutrient mitigation , also known as nutrient neutrality, ensures that new developments do not contribute to nutrient loads in water bodies where protected sites (or habitat sites) are in 'unfavourable condition' due to the polluting effects of excessive nutrients. However, BNG has an additional planning burden and cost to development for under-resourced local administration making it often difficult to implement.

Voluntary markets in the UK are mainly established for peatland and woodland carbon credits. The CCC's 2022 report on 'Voluntary Carbon Markets and Offsetting' investigates measures to ensure the integrity of carbon offset projects avoiding potential damage to other priorities such as climate adaptation and biodiversity[14]. However, there is a lack of consistent regulation and enforcement for 'Voluntary Carbon Markets and Offsetting'. In addition, existing market codes - such as Interim Principles for Responsive Investment in Natural Capital in Scotland, or the Peatland Carbon Code at the UK level - do not fully capture all possible NbS benefits (Adaptation Scotland 2023).

Carbon credits can support adaptation actions in water and flood risk catchment management. A new water credit system is being tested in the Greater Cambridge area by the government to address the deficit in water supply until water companies build major infrastructure. In this system, developers can offset their development by purchasing and selling water credits to ensure they have a neutral impact on water scarcity within Cambridge (DEFRA 2024). Another interesting example is in Washington DC where Stormwater Retention Credits (SRCs) allow to earn revenue for projects that reduce harmful stormwater runoff by installing green infrastructure (GI) or by removing impervious surfaces[15].

13 https://assets.publishing.service.gov.uk/media/65a11af7e8f5ec000f1f8c46/NPPF_December_2023.pdfnutrient-mitigation
14 The UK Government is supporting the Voluntary Carbon Market Integrity Initiative to develop clear guidance to help ensure that the use of voluntary carbon markets is in addition, and not as an alternative, to ambitious action by companies seeking to reduce their direct emissions and at the same time delivers the greatest benefits for nature protection and restoration. The Government is also working with industry leaders from the land management, business, finance and environment sectors through the Financing UK Nature Recovery coalition to develop a roadmap for scaling up high-integrity environmental markets in the UK.
15 https://doee.dc.gov/src

Recommendation to Regulators: Integrating measurement of adaptation outcomes into existing and emerging compliance nature and carbon market standards and codes.

Recommendation to Regulators: Consistent regulation and enforcement of private NbS markets (i.e. 'Voluntary Carbon Markets and Offsetting) is important for ensuring standards of quality without limiting NbS implementation.

3.3 Value Capture Through Property Appreciation – Using Nature in Real Estate

Biodiversity and climate adaptation can be delivered in real estate, leveraging building codes and new legislation such as through BNG. Countries are working to integrate NbS into building codes, such as requiring a minimum for green space areas on and around new buildings and permeable material in driveways to increase water absorption and retention capacities (OECD 2021). A major challenge is the lack of data or poor quality, compounded by unclear definitions and numerous reporting frameworks. Better data and frameworks are needed for transparency and comparability.

There is an opportunity to make mandatory nature-based solutions in real estate including resilience solutions, leveraging Biodiversity Net Gain Legislation[16]. In fact, there are several important standards and guidance in development in the market:

- TNFD guidance will play an important role in raising awareness of the centrality of nature, biodiversity, and functioning ecosystems to long-term financial sustainability. Of particular relevance is the development of market-first UK commercial real estate guidance for TNFD-aligned disclosure and reporting.
- The UK Green Building Council (UKGBC) is working on 'Biodiversity and Environmental Net Gain (BNG & ENG)' and 'Embodied Ecological Impacts of the Built Environment'.
- Green and sustainability certification (i.e. BREEAM/GRESB) can be leveraged to issue Green Instruments and Sustainability-linked Instruments for adaptation.
- The UK Net Zero Carbon Buildings Standard provides an industry-agreed standard for Net Zero for anyone who wants to fund, procure, design, or specify a Net Zero building. It will align with science-based targets and apply to existing and new buildings.

Recommendation to standard setters' organisations: Provide fewer, clearer, and simpler definitions for resilience standards in real estate to enhance transparency and boost confidence in the market's integrity. Resilience standards reduce uncertainty and help to de-risk projects for potential investors while enabling technical certification.

Recommendation to real estate developers: Undertake green real estate investment and implement nature-based solutions with explicit resilience benefits such as green roofs or sustainable drainage systems in their projects, mirroring the UK green building standards focused on improved energy efficiency within the Future Homes Standard.

3.4 Developing Green Financial Instruments

Green Instruments can raise finance needed for adaptation and resilience. As seen in the case studies, a revolving fund for wastewater treatment and stormwater drainage improvements cannot only monetise savings but also increase property values and rental yields. Crowdfunding at municipal and local levels can address constraints due to lacking resources and financing.

Case study findings and estimates for the UK reveal a stark reality: a tiny proportion of green bonds are currently used for adaptation and resilience financing. While sustainability-linked bonds and loans in resilient buildings and water efficiency are rapidly growing, the inclusion of climate resilience is still limited. The NatWest Group case study in Part I and CBI estimates for the UK show how only a small proportion of green bonds are used for adaptation and resilience financing. Green Bond adaptation issuance, focusing on water management and flooding risk, offers good examples of financial instruments with large-scale investment projects and quantifiable metrics (i.e. flood protection, other flood defences, pumping stations, sustainable use of water and water shortage management and data-driven climate monitoring). For example, for the Dutch NWB Bank 5-year Water (Green) Bond, in 2022, the proceeds will

16 For new development this is happening through the implementation of Schedule 3 of the Flood and Water Management Act in England (due 2025), already implemented in Wales.

go towards flood protection across the Netherlands, with the green indicator (i.e. impact metric) being "kilometre of regional flood defences that meet safety standards."

Insurance will become ever more important to protect the resilience of the most vulnerable part of the population (beyond public schemes such as Flood Re). Research suggests an important protection gap as around 40% of UK commercial property is underinsured to physical climate risks[17]. As seen in Singapore, there is a need in the UK and Europe for better data for climate and alternative risk transfer instruments such as insurance-linked securities, captive insurance, and sovereign catastrophe risk pools. The Nanyang Technological University's Institute of Catastrophe Risk Management, working with the ASEAN governments and secretariat, has built an integrated data and analytics platform for flood, typhoon, and earthquake risks for ASEAN countries - ASEAN Disaster Risk Financing and Insurance Phase 2 Initiative (ADRFI-2).

Recommendations to UK Government

- **Provide guidance to develop metrics for adaptation and resilience** from the forthcoming UK Green Taxonomy and the Green Gilt and Green NS&I Bond programmes. This work can leverage International Best Practices on Green Bonds, ensuring alignment with the International Capital Market Association (ICMA) Green Loan / Bond Principles and contribute to UNDRR's new work on climate resilient classification framework to facilitate investment in climate resilience through capital markets developed by the Climate Bond Initiative (CBI 2024).
- **Issuance of the first dedicated UK Government adaptation bond**, supporting local, municipal, and national adaptation projects. This can take the form of Sovereign Bonds - Green Gilts - and dedicated national adaptation bonds, such as the Adaptation Bond for Resilient Infrastructure by the AIIB[18].
- Revise fiscal policy with **tax exemptions for adaptation projects** being implemented. One opportunity in this area is "adaptation bonds", a new asset class modelled after US municipal bonds[19].
- Leverage the Green Financing Programme (Green Gilt) will help catalyse further growth of the **corporate green bond market** in the UK, as there is significant demand from investors for liquid green debt securities.
- **Explore sustainability-linked bonds and loans in Real Estate** leveraging BNG regulation. Identify and explore financial instruments for risk management financial products innovation in the UK, such as **disaster, catastrophe bonds, and parametric insurance products**, in close cooperation with relevant stakeholders (i.e. EIOPA or Singapore Green Finance Centre).

4. Mobilising Private Sector Investors

4.1 Better Risk Assessment for Climate and Nature Physical Risk

Physical risk is currently under-estimated by investors. Managing the impact of physical climate risks is part of investors' fiduciary duties. However, investors might underestimate risks at the portfolio level due to asset risk consideration and reporting under the TCFD framework, not considering the potential impact of several compounding climate hazards (e.g. heatwaves and overheating, beyond flooding) or secondary and indirect impacts. Case studies also highlighted indirect impacts on banks' loan books (i.e. on agriculture loans) of the UK's most significant physical climate risk: flooding.

Climate change and nature deterioration have been recognised as a financial risk by central banks and regulators. According to a recent report by the European Central Bank (ECB) and the European Systemic Risk Board (ESRB), it has been highlighted that the climate physical risk of bank lending portfolios extends beyond transition risk (ECB & ESRB 2023). The report indicates that in Europe, over 50% of total loan exposures to firms in the mining, water supply, and wholesale sectors are impacted by extreme flood risk. In addition the preliminary findings from the same report indicate that nature degradation has the potential to cause significant impacts, both chronic and acute. Chronic physical risks are expected

17 https://www.ajg.com/uk/news-and-insights/2022/december/over-40-percent-of-commercialpropertiescurrentlyunderinsured/#:%7E:text=5%20December%202022&text=In%20research%20amongst%20business%20owners,liable%20to%20pay%20the%20difference.
18 https://www.aiib.org/en/news-events/news/2023/AIIB-Issues-First-Climate-Adaptation-Bond-Targeting-Resilient-Infrastructure.html
19 More about this can be found in Bob Buhr's research at the CCFI here: https://www.imperial.ac.uk/business-school/faculty-research/research-centres/centre-climate-finance-investment/research/adaptation-bonds-lessons-the-us-municipal-bond-market-help-closethe-adaptation-financing-gap/

to accumulate in the agricultural and related sectors, with acute physical risks primarily pertaining to freshwater.

Financial regulation and supervision have a key role in incorporating physical climate risks into the risk management practices of companies and financial institutions. This ensures financial stability, assesses macro-level and systemic physical climate risks and resilience, allows access to finance and eliminate greenwashing, price physical risk, and sets standards for resilience-linked financial instruments. The Bank of England's Climate Biennial Exploratory Scenario exercise has shown that UK banks and insurers are making progress in some aspects of their climate risk management but still better risk assessment is needed.

However, there is a lack of an integrated approach to climate risks. Climate risk and vulnerability assessment should be considered at asset and portfolio level, with a quantitative financial assessment necessary to build the private sector rationale for investment and risk management. In addition is necessary to link climate change and extreme weather to financial projections. Multiple hazards, such as wildfires and heatwaves, and system impacts, such as ecosystems and food systems, need to be integrated into the risk analysis.

Recommendation for Bank of England: Explore and further address physical climate risk challenges by integrating financial risk metrics (disaster and climate risks) so that investors can fully understand their portfolio risks. Engage with international partners such as MDBs and NGFS's working group on Adaptation financing.

Recommendation for Bank of England: Strengthen physical risk assessment requirements, such as the Climate Biennial Exploratory Scenario and enlarge the participant pool.

Recommendation for Bank of England: Explore further the relationship between climate risks and regulatory capital building on previous work (Bank of England 2021, and Bank of England 2023).

Recommendation for Defra and Bank of England: Engage with Defra to explore the risk of nature loss and degradation and financial risks, leveraging international efforts.

4.2 Climate Risk Disclosure as Market Catalyst

New operational frameworks (ESG + R), including resilience outcomes, are required. An essential component of climate change adaptation is climate risk disclosure and assessment, with key frameworks being the EU Taxonomy, TCFD requirements or the forthcoming UK Green Taxonomy. Shortcomings of current initiatives are the focus on process rather than outcomes and the lack of granularity at the sector level. As highlighted in the case studies, new operational frameworks, including resilience for financial institutions—Environment, Social, Governance and Resilience (ESG+R)—can help lower perceived risks for private investors, therefore unlocking additional financing and funding streams

There is no common agreement on the set of frameworks and indicators to be used for resilience and adaptation. For example, there is no single comprehensive set of criteria for ESG in infrastructure that is universally recognised, limiting the usefulness of current multiple ESG frameworks for infrastructure resilience. At the same time, there is insufficient evidence to confirm how positive ESG scores increase investment in resilience. The ESG+R Framework developed by the UK Infrastructure Bank for the environmental assessment of the Thicket Water Reservoir could be used as a starting point for similar projects.

Several initiatives are promoting a common approach to resilience identifying sustainable, quality, and/or green infrastructure projects. These include several 'meta-standards', such as FAST-Infra label (Finance to Accelerate the Sustainable Transition-Infrastructure), the SuRe standard (Standard for Sustainable and Resilient Infrastructure) and the Blue Dot Network (BDN)[20]. As seen in the Glen Dye Case study, Net Zero strategies aligned with government objectives can also bring adaptation benefits. There is an opportunity to leverage upcoming disclosure requirements from TPT Transition plans to become mandatory following the FCA decision to include resilience benefits.

20 FAST-Infra, led primarily by finance-sector institutions, launched the Sustainable Infrastructure Label to identify sustainable infrastructure projects. SuRe is a third-party verified global voluntary standard developed by Global Infrastructure Basel (GIB). The American, Australian and Japanese governments introduced the Blue Dot Network framework to certify quality infrastructure projects (US Department of State, 2019).

Climate change adaptation is recognised as an eligible category in taxonomies and regulations. This is the case by various voluntary process guidelines (e.g. Green Bond Principles and Green Loan Principles) and within regulated reporting standards (e.g. EU Sustainable Finance Taxonomy; Singapore-Asia Taxonomy for Sustainable Finance). However, these guidelines and standards address adaptation at a high level while there is a pressing need for more detailed guidance to specify eligible activities within these categories UNDRR (2024). There is a need to go beyond a process-based approach such as the one used by the EU Taxonomy, adopting quantitative indicators at a more granular level. This will allow the development and structuring of financial products focused on adaptation and resilience, such as loans, bonds, private placements, structured notes, letters of credit, and deposits.

Recommendation for HM Treasury and Investors: Develop adaptation metrics and guidance within the IFRS Sustainability Disclosure Standards and partnerships with the private sector to support delivery. Beyond the recent addition of biodiversity as a target RI theme, consider an ESG + R framework (this work could build on guidance from CBI (2024) and UNDRR (2024) Guide for Adaptation and Resilience Finance, Standard Chartered and KPMG, UNDRR: Geneva, Switzerland)

Recommendation to Investors: Integrate in portfolio approaches Mitigation, Adaptation and Nature, exploring synergies between TCFD and TNFD in the new UK Green Taxonomy.

Recommendation to Financial Regulators and Investors: Build upon TCFD and ensure that the TPT standards set expectations for the assessment and disclosure of physical climate risks and adaptation plans across the economy.

Recommendation to standard setters' organisations for Infrastructure/Water sector & ESG Standards: Ensure the meta-standards under development, such as FAST Infra Label or the Blue Dot initiative for infrastructure, are fully aligned and address the user needs across all infrastructure subsectors.

Recommendation for Investors: Employ impact investing strategies focused on adaptation.

4.3 Adaptation and Resilience as an Investment Theme

Investment vehicles for long term investors

The small scale of pension funds is seen as a barrier to investing in adaptation and resilience. The need to consolidate defined contribution (DC) and defined benefit (DB) pensions into pools with greater investment clout is a recurring topic in the UK policy debate. The Department for Work and Pensions issued a call in 2023 for evidence as to whether defined benefit plans in the UK would benefit from increasing investment in productive finance, including infrastructure. In 2023, the government announced an allocation objective for DC funds by 2030 of at least 5% of their default funds to unlisted equities with the British Business Bank to provide advice on investment vehicles[21].

Pension fund pooling can offer investment advantages and represent long-term investors for stakeholder capitalism. The accelerated transfer of the £364 billion Local Government Pension Scheme assets into pools allows cost savings whilst enhancing performance and investment in UK infrastructure. The Financial Conduct Authority (FCA), needs to authorise any change in regulation, being the UK's financial services regulator.

Recommendation for the Department for Work and Pensions and Financial Conduct Authority (FCA) explore pension fund pooling investment advantages including representation of long-term investors for stakeholder capitalism.

New guidance on fiduciary duty for pension funds

Sustainability and climate change have added complexity to pension funds' investment strategies and decision-making. Respondents to a recent Government call for evidence suggested there is a lack of clarity around how fiduciary duty interacts with sustainability and climate change considerations[22]. Financial

21 https://www.gov.uk/government/collections/mansion-house-2023
22 See the Government's response to that call for evidence "Pension trustee skills, capability and culture". Published 22 November 2023 https://www.gov.uk/government/calls-for-evidence/pension-trustee-skills-capability-and-culture-a-call-for-evidence/outcome/

risk and return on investment can be affected by changes in behaviour and conduct, law and regulation, economies and finance, confidence and reputation. Increasing dispute or litigation risk in connection to climate change implies possible adverse outcomes and additional costs and uncertainty[23].

Fiduciary and prudential responsibilities may represent significant barriers to investing in adaptation and infrastructure. According to a recent analysis from LSE, current guidance on and interpretations of fiduciary duty discourage pension fund trustees and other fiduciaries from allocating funds to investments that deliver a positive economic, environmental or social outcome as well as a financial return (LSE, 2023).

Climate change affects pension funds at multiple levels as participants in much wider financial and economic networks. Financial considerations must be carefully evaluated across various levels, including the specific asset or investment, the portfolio, and the broader economic landscape relevant to the pension fund. More clarity and significance is needed for concepts such as double materiality and dynamic materiality, real-world impact, "universal owner" risk (Financial Market and Law Committee 2024).

Recommendation to Pension Fund Regulator: Clarify pension funds' fiduciary duty issues such as time horizons, changes in return over time and systemic risk in the context of climate resilience.

Recommendation to the Financial Reporting Council (FRC) Department for Work and Pensions, the Pension Regulator and FCA: Review the regulatory framework for effective stewardship for risk management, including the Stewardship Code.

Blended finance and role of UK Infrastructure Bank

Despite the potential to leverage blended finance, more investment needs to flow into adaptation. Currently, public finance institutions have focused more on climate change mitigation. **Strategic use of public finance** can facilitate private investment and finance for adaptation action, with examples including public sector provision of concessional guarantees, first loss tranches of debt structures, performance wraps (insurance), and subordinated debt.

Use international experience for domestic purpose. Over the past decade, the UK has developed significant international experience in blended approaches through the UK Export Finance, the British Business Bank and the UK Infrastructure Bank. These organisations can become critical advocates for investing in Adaptation by gathering case studies of best practices and thus building a track record and trust signalling in financing adaptation. Grants instruments and guarantees should allow for capacity building and blended finance options, similar to the Export Credit Agencies.

The UK Infrastructure Bank (UKIB), launched in 2021 and now transformed into the new National Wealth Fund could have an essential role[24]. It aims to accelerate investment in infrastructure projects, support the Government's Net Zero and level up ambitions. The bank's primary goal is to de-risk infrastructure investments and attract private capital[25]. As seen in the Part I Case Studies Analysis of this policy brief, the bank had a key role in providing financing to the first reservoir in the UK for a long time and producing a new framework for investment, including resilience along with ESG factors. Best practices for adaptation can be learned from the experience of international actors such as the Asian Infrastructure Investment Bank and the European Investment Bank.

government-response-to-pension-trustee-skills-capability-and-culture-a-call-for-evidence

23 See Grantham Research Institute on Climate Change and the Environment (LSE) and the Sabin Center for Climate Change and the Law (Columbia Law School). https://www.lse.ac.uk/granthaminstitute/wp- content/uploads/2023/06/Global_trends_in_climate_change_litigation_2023_snapshot.pdf.

24 The UK Infrastructure Bank has become the National Wealth Fund, with a broader remit, more capital and a greater capacity for risk.

25 With its initial £22 billion of financial capacity, the bank aims to deploy up to £3 billion of debt and equity and £2.5 billion of guarantees a year, committing our £22 billion over the next five to eight years, subject to the pipeline of investable projects in each year.

Recommendation to the UK Infra Bank, Treasury and Green Finance Institute: Attract national and international institutional investors by increasing blended finance for adaptation, leveraging the experience of the Green Investment Bank and international blended finance instruments developed by MDBs targeting international institutional investors.

Recommendation for UK Infra Bank, British Business Bank, Climate Change Committee, Green Finance Institute: Include adaptation as a priority in all investors, agency, and government investment strategies (e.g., through targeted concessional finance) and reaffirm it as a part of their remit and a priority. Best practices for adaptation can be learned from the experience of international actors such as the Asian Infrastructure Investment Bank and the European Investment Bank. Given the potential synergies between climate and nature, the government should review the case to broaden the UK Infra scope of activity to UK's natural capital.

5. Nature, Knowledge Systems and Capability at the Local Level

5.1 Nature-Positive Infrastructure in Cities

Spatial planning in cities: Integrating NbS, social sustainability and financing

London is currently grappling with a severe housing crisis, affecting the most vulnerable members of the population. A recent report "Housebuilding in London: London Plan Review", commissioned by the Department for Levelling Up, Housing and Communities analysed major barriers for the shortfall of over 60,000 homes compared to established targets. The report found evidence that the multiplicity of policies in the London Plan makes the application process expensive and time-consuming, especially for small and medium enterprises.

The case studies show that actions to enhance green infrastructure occur at different scales, from urban and single neighbourhoods to the broader rural landscape. Spatial planning, a crucial task for local governments, determines the role of NbS in housing, infrastructure development and land preservation. Given the critical role of local governments in spatial planning, countries have issued national guidance and developed tools to help promote the integration of NbS and resilience into local land-use plans. This approach has been successfully integrated in the update to the National Planning Policy Framework published in December 2023 and the London Plan Spatial Development Strategy for Greater London published in March 2021[26].

26 The London Plan, comprises separate chapters relating to several areas, including London's Places, People, Economy and Transport. Regarding ecology and the built environment, Green Infrastructure aims to protect, promote, expand, and manage the extent, quality of, and access to London's open and green spaces network. Urban Greening encourages the 'greening of London's buildings and spaces, specifically those in central London, by including a target for increasing the area of green space (including green roofs, etc.) within the Central Activities Zone.'

Recommendation to Government: Integration of NbS in local spatial land-use plan. Dedicated grant funding could be considered as part of the model to incentivise the use of integrated, nature-based solutions approach in dedicated 'green zones' (CCC 2023).

Recommendations to Government: Adopt a government institutional investment mechanism, such as the Climate Ready Clyde mechanism[27], a cross-sector initiative supported by the Scottish Government to create an adaptation action plan for Glasgow City Region.

Recommendations to GLA: Introduce an overarching policy and one-stop-shop agency for residential development to assist applicants and decision- makers which would bring together all the relevant issues in any given case of an application, including also adaptation impact .

Recommendation for local authorities: Adopt a systematic approach to addressing adaptation barriers in cities to ensure local inclusion and social sustainability. This could be done though interdisciplinary committees and network collaboration.

Recommendation: Improve communication and dialogue on Adaptation Financing best practices. Prioritise adaptation financing across different work streams.

- **Investor networks and organisations** such as the Centre for Greening the Financial System, London Climate Change Partnership, city networks, Grantham, and Centre for Climate Finance and Investment should strengthen advocacy, education, training, knowledge tools, research, and **conferences on financing adaptation.**
- **Public-private task forces** established by the end of 2024 to define sector adaptation roadmaps and clear investment plans aligned with national goals.

Recommendation for investors: Complement the existing adaptation groups with ones focusing solely on adaptation financing and embed adaptation into the work of these groups - Transition Plan Taskforce workstream on Adaptation Plans by the HM Treasury; Climate Financial Risk Forum Working Group on Adaptation, co-chaired by the Green Finance Institute and Impax Asset Management; IIGCC Adaptation and Resilience Project Group.

Building with nature: Integrating NbS in delivery of infrastructure & water supply protecting the environment

Investing in nature-positive infrastructure in cities remains crucial to addressing biodiversity loss and climate change impacts. Urban vegetation, including street trees, green roofs, green walls in urban green spaces, and green buildings, can be a crucial adaptation measure for heat and air pollution risks and enhance biodiversity. Bioswales, rain gardens, and retention ponds can improve flood management and soil quality.

Land managers who leverage BNG guidance and knowledge will be able to enhance the future management of natural assets. The resulting Biodiversity Frameworks developed by real estate developers should be associated with emerging drivers, including the Taskforce for Nature-related Financial Disclosures.

Recommendation: In real estate, leverage TNFD disclosures likely to increase the focus on the biodiversity impacts of existing assets and portfolios, whereas BNG legislation focuses on new developments.

A nature-positive approach can contribute to developing new infrastructure projects whilst delivering better environmental and biodiversity outcomes in line with the 25-Year Environment Plan. Hybrid approaches are emerging that integrate ecological and grey (engineered) infrastructure in adaptation planning and hazard protection (Grimm et al., 2016; Depietri & McPhearson, 2017). From 2025, the government will require new nationally significant infrastructure projects to achieve biodiversity net gain, with habitats secured, managed and maintained for at least 30 years.

27 Climate Ready Clyde – see more here: http://climatereadyclyde.org.uk/wp-content/uploads/2021/09/10-Annex-3-Resource-Mobilisation-Plan.pdf.

Recommendation: In Infrastructure sectors such as transport, water and flood risk management, Government should build on its commitment to biodiversity net gain by requiring sectors to take a strategic approach to enhancing natural capital across their assets, understanding co-benefits of NbS inclusion and implementing pilot projects to build the knowledge base.

Increasing the scale of investments for NbS

The private sector forms of finance available for adaptation are limited and directed to large-scale grey/physical engineering projects. The small size of adaptation projects implies higher costs and time for implementation (Cooper and Trémolet, 2019; World Bank, 2020b). Aggregating or bundling smaller projects, particularly for NbS, is possible to obtain the economies of scale necessary to reduce transaction costs and become attractive for private investment. For example, several hundred small water projects can be bundled as a single aggregated project to make it bankable for investors[28].

The UK government is investing £30 million in the Big Nature Impact Fund (BNIF), a new blended finance impact fund managed by Federated Hermes and Finance Earth. BNIF will accelerate the creation across England of high-integrity nature projects that generate revenue from ecosystem services such as biodiversity and carbon sequestration by creating biodiverse woodlands and other priority habitats and restoring peatlands. By taking a blended finance approach and aggregating these projects up to an investible level, BNIF will help lower transaction costs and reduce risks, bringing the risk profile of these projects in line with institutional investors' appetite.

Recommendation to Developers and Investors and Lead Local Flood Authorities: Aggregating nature-based solutions (NbS) for the water sector will make them more investable by providing scale and potentially spreading risks. This could build on the example of the Big Nature Impact Fund (BNIF), which will leverage private sector investment in a range of nature projects in England.

5.2 Local Green Finance and Place-based Investment Models

The UK government is working to increase the volume of private sector investment activity in local green projects, supporting new and innovative approaches. This includes blended finance in place-based approaches such as the Local Net Zero Forum and supporting the growth of the municipal Green Bond market. As part of the Prime Minister's Business Council convened in 2022, Lloyds Banking Group, Octopus Energy, Shell and National Grid launched a Local Low Carbon Accelerator partnership to provide a blueprint for local authorities and the private sector to work together and deliver green infrastructure. UKIB have supported its projects, providing expert advice throughout the process.

Establishing local-sectorial adaptation strategy plans and targets is essential for developing the local municipal bond market in the UK. In Part 2 of this analysis we looked at Copenhagen's innovative funding mechanisms to protect against extreme rainfall and flooding (referred to as Cloudburst), utilising a water tariff and 'KommuneKredit,' a municipal pooled credit facility. As seen in the Part I case studies, there are opportunities at the local level to extend the green gilts and bonds offered by the government and National Savings and Investment (N&SI) to allow investors and retail savers to contribute to the supply of capital for adaptation. Another financial instrument with potential is pooled procurement, which typically involves aggregating demands from multiple cities or projects to purchase goods or services in bulk for lower prices (Macedo, F., Steinbach, D., 2023).

Singapore has an ambitious urban adaptation approach that is widely considered a model among capital cities elsewhere. It has succeeded in developing a whole government approach to adaptation that sets a clear transition pathway to a climate-adapted city. As with London, Singapore functions as a financial hub for the region. For example, in 2013, Singapore planned to become a global insurance marketplace. Today, Singapore is Asia's leading reinsurance hub with a market share of 24%, and 16 of the top 25 reinsurers in the world have made Singapore their regional hub. Global reinsurers are developing digitalisation, data analytics, and sustainability solutions for bespoke disaster risk financing, carbon credits, and renewable energy infrastructure.

28 An area currently being investigated is the large scale implementation of SuDS , refer for example to https://www.lotag.co.uk/londonstrategic-suds-pilot-study

Recommendation for Greater London Authority, UK Treasury and UK Infrastructure Bank

- Establish local-sectorial adaptation strategy plans and targets, in the development of a local municipal bond market in the UK including considering resilience within local net zero ambitions and climate mitigation projects, as well as natural capital projects.
- Engagement of local authorities with businesses and investors to develop place-based adaptation investment models, exploring crowdfunding options and climate bonds at the local level, and development of a Municipal Green Bond market in the UK.
- Strengthen local and government planning regimes for adaptation and resilience by 2030. Reintroduce a statutory duty for the public sector to adapt to climate change in England.
- Create an Urban Taskforce for Greater London to scope bankable projects, match-make investors, and set up financing mechanisms.
- Follow the European Union's Horizon Europe project[29] to get inspiration for developing strategies and contribute to knowledge sharing for the GLA.
- Strengthened UKIB role in supporting local capability.
- Strengthened Financial Conduct Authority role in authorising and regulating financial products.
- London as a global insurance marketplace reinforcing links with emerging markets (i.e. Singapore).

5.3 AI and Climate Data analytics

Green fintech is offering new solutions for climate physical risk. In particular new solutions are emerging to measure, manage, and minimise physical climate and nature-related risks and help optimise green insurance products and services (CGFI 2024). The utilisation of Earth observation satellites, sensors, and UAV platforms has significantly reduced the expenses associated with the collection of expensive environmental datasets. Furthermore, advancements in artificial intelligence (AI) and the implementation of natural language processing models have further streamlined the processing of large environmental datasets, resulting in unprecedented speeds and heightened accuracy.

Artificial intelligence is opening new fields of scientific and academic research such as climate attribution and litigation. Better climate risk attribution can improve risk models used by insurers, lenders, and investors, leading to better risk assessment, precise pricing of climate risks, and accurate allocation of financial resources for adaptation[30]. NPL models have been used to better understand the extent to which firms are adapting to climate change and building resilience to climate and nature-related risks (Spacey Martín R. et al 2024). To show that local institutional ownership mitigates the negative impact of extreme weather events on stock prices, a recent study exploits Geographic Information Systems (GIS) to determine the exposure of firms to extreme weather events by overlaying the locations of production facilities with affected geographic regions (Bauer R., Broeders D. and De Carolis F. 2024).

Fintech and sustainable finance initiatives for climate resilience have been actively promoted and supported in Singapore. The Monetary Authority of Singapore (MAS) launched Project Greenprint in 2023, a blockchain-based network of registries to control the provenance of ESG certifications and verified data. Climate Impact Exchange, launched in 2023, uses Earth Observation technology, machine learning, and blockchain to trade nature-based carbon credits. However, with opportunities, AI solutions also present significant challenges. The Singapore Green Finance Centre, a partnership between Imperial College and Singapore Management University, is also an initiative gathering major financial institutions in the region. The increasing demand for Data Centres (DC) services puts pressure on energy supplies, water resources, and land availability. Consequently, unchecked expansion of DC requirements can compromise Singapore's climate ambitions, including its target to achieve net zero emissions by 2050. It may disrupt resource allocation and urban planning in this already water-scarce and land-constrained city-state. Therefore, while synergies between Fintech and sustainable finance are promising, the broader trend towards digitalisation in economic and financial realms necessitates careful consideration of associated trade-offs.

Several initiatives at the international level facilitate access to critical granular and localised data, products, applications, indicators and services. The European Space Agency is advancing the use of digital tools for adaptation through data platforms such as Copernicus Climate Change Service, namely Copernicus Data Space Ecosystem and WEkEO. Digital Europe Programme and Destination

29 https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

30 Climate Attribution uses statistical analysis and climate modeling to compare observed weather events with simulations of what the climate would have been like without human impact, quantifying the difference in intensity and likelihood of an extreme weather event. This could underpin, connecting polluters to real world climate impacts opening also climate litigation potential.

Earth initiatives, include creating Artificial Intelligence (AI)-enabled local digital twins[31]. Horizon Europe will continue supporting research to deliver large sets of high-resolution, seamless multi-decadal climate simulations to better characterise local risks and uncertainties.

Recommendation to industry, BoE and UK Treasury: Promote and support the use of the Risk Data Hub to harmonise the recording and collection of comprehensive and granular climate-related risk and losses data and promote national-level public-private partnerships to collect and share such data (connect to similar exercise at the European level from EIOPA).

Recommendation to Academia and Industry:

- Collect Data and establish a repository on Cost of Capital for Adaptation projects at Imperial College building on the Observatory of Cost of Capital initiative by IEA, ETHC Zurich WEF and Imperial College.
- Ensure that the new UKRI climate change adaptation hub – can coordinate new transdisciplinary knowledge for UK climate adaptation also at an international level engaging with EU Horizon research and funding.
- In collaboration with ESA and the UK Centre for Greening Finance and Investment (CGFI) explore new adaptation research possibilities from AI, digital twins big data and disruptive tech, encouraging the sector to use more open data
- Propose an academic course on Adaptation and Resilience Financing for Business schools, bringing together science and finance and allowing a multi-disciplinary approach across sectors i.e. water, agriculture, infrastructure.

31 Destination Earth, see https://digital-strategy.ec.europa.eu/en/policies/destination-earth.s

Glossary

Adaptation financing gap	The adaptation financing gap refers to the difference between adaptation funding requirements and financing being made available. The United Nations Environment Programme publishes an annual report on the status of this gap. For 2022, please find it here: https://www.unep.org/resources/adaptation-gap-report-2022.
Blended Finance	Blended finance' is a catch-all term that covers financial products or structures that combine different funding sources aimed at lowering the risk profile of specific companies or projects and ultimately attracting private capital (UK Treasury 2023 Green Financer Strategy).
Climate proofing	Climate proofing refers to a process that integrates climate change mitigation and adaptation measures into the development of infrastructure projects (European Commission, 2021).
Green infrastructure (also Blue Green Infrastructure)	A strategically planned network of natural and seminatural areas with other environmental features, designed and managed to deliver a wide range of ecosystem services, such as water purification, air quality, space for recreation and climate mitigation and adaptation while also enhancing biodiversity (EU, n.d.). Green infrastructure can include green spaces, but also schemes that are alternatives to engineered (grey) infrastructure such as sustainable drainage systems or green flood control management. It can include green infrastructure in new developments, upgrading of existing green infrastructure and retrofitting of new green infrastructure.
Greenium (green premium)	Pricing benefits based on the logic that investors are willing to pay extra or accept lower yields in exchange for sustainable impact (UNDP, 2022).
Land value capture	Land value capture is a policy approach that enables communities to recover and reinvest land value increases that result from public investment and government actions. Land value capture is rooted in the notion that public action should generate public benefit (OECD, n.d.).
Nature-based solutions	Actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature (IUCN, n.d.).

Physical risk	Physical risks are risks associated with impacts of climate change, such as the risks stemming from extreme weather events and changing climate patterns. Transition risks are those associated with the pace and extent at which an organisation manages and adapts to the internal and external pace of change to reduce greenhouse gas emissions and transition to renewable energy (US EPA, 2023).
Revolving fund	An amount of money that exists in order to finance something, but from which any loans must be replaced in order that the full amount is available again (Cambridge Dictionary, n.d.).
Sustainable drainage systems	Sustainable drainage systems (SuDS) are drainage solutions that provide an alternative to the direct channelling of surface water through networks of pipes and sewers to nearby watercourses. By mimicking natural drainage regimes, SuDS aim to reduce surface water flooding, improve water quality and enhance the amenity and biodiversity value of the environment (BGS Research, n.d.).
Transition risk	Transition risks are those associated with the pace and extent at which an organisation manages and adapts to the internal and external pace of change to reduce greenhouse gas emissions and transition to renewable energy (US EPA, 2023).
Voluntary carbon markets	Voluntary carbon markets allow carbon emitters to offset their emissions by purchasing carbon credits emitted by projects targeted at removing or reducing greenhouse gas from the atmosphere (EEX, n.d.).

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