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SME NATURE POSITIVE INNOVATION FINANCE REPORT

Early-stage nature positive innovation finance in the UK

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Executive Summary

The UK's early-stage enterprise sector (i.e. start-ups) is of vital interest in understanding how innovative practices and ideas are being catalysed to support sustainable business models that can respond to both the climate and ecological challenges of our time. Start-ups are a key segment of the Small and Medium-sized Enterprise (SME) economy, acting as innovators and catalysts of (often) disruptive business activity, and notably in green environmentally positive sectors. External investment can enable these potential disruptors to grow and scale and make environmental impacts.

Early-stage investment markets are complex and triage founders towards different types of external financing along the innovation finance escalator (Figure 4) ranging beyond initial friends and family networks to include public and private financing - often in combinations, which may involve debt (loans) or equity (ownership share investment). Due to the high levels of risk involved, most innovative start-ups requiring external financing will seek equity funding, typically from business angels and venture capitalists (VC), or through accelerators and crowdfunding platforms.

The structure of financial arrangements is influenced by governance, market opportunities and how early-stage businesses find routes to investment. Importantly, both founders and financiers participate in an ecosystem of value-based agreements, which can stem from agreeing on purposeful investment (demonstrating added social and nature value) first, then assessment of patient capital (investment horizon) and risk appetite (the likelihood and scale of return on the amount of capital invested), as well as how certain outcomes are measured and evaluated by both sides.

This report focuses on the UK early-stage green innovation finance market, addressing two key research questions: (i) **how to measure and report green nature-positive financial risk and mitigation impacts** and (ii) **how to deliver an effective SME green nature-positive finance market**?

The study is part of the Middlesex University (MDX) *SME Nature Positive Finance* project, one of twelve projects under the flagship Integrating Finance and Biodiversity (IFB) programme funded by the Natural Environment Research Council (NERC) and Innovate UK (IUK). This project adopted a longitudinal approach. Initially, this drew on existing literature and the (limited) available secondary data on UK SME green finance. Subsequently, to gain greater insights into the nascent, evolving UK SME green innovation finance market, the study included a predominately qualitative outreach approach with 100s of respondents and attendees in different project events as well as through undertaking purposively selected in-depth interviews. In this report, we reflect on the financial landscape affecting SME nature-positive finance, drawing on the insights of 88 stakeholders in the UK SME green innovation finance ecosystem who were interviewed during the period 2022-25. This included public and private financiers, policy-makers and support agencies and 10 detailed case studies of SME ecological services innovators[1].

We recognise that the green finance landscape is rapidly evolving, not least with companies and policy regimes increasingly incorporating an awareness of the need to consider biodiversity alongside the 'carbon tunnel vision' of addressing net-zero (Konietzko, 2022). However, recent UK

1 Key case studies are available on our project webpage: https://cusp.ac.uk/projects/sme-finbio/

governmental momentum on net-zero shows signs of flagging and it is vital to protect nature and demonstrate that investment regimes can effectively, genuinely and sustainably, embed nature into their decision-making and regulatory practices.

Our study offers greater understanding of the operation of UK nature-positive innovation start-up financing and the roles that Small and Medium-size Enterprise (SME) innovators perform in developing biodiversity measurement and monitoring that inform and shape the emerging nature-positive finance market. In this report, we reveal a nascent, often disparate and complex SME innovation funding market for green innovation, which remains well short of fully understanding biodiversity and nature-positive.

The major drivers of nature-positive market developments are often *top-down*, via regulatory environmental, social and governance (ESG), large firm reporting and the concerns of longer-horizon institutional investors, insurers and banks who are required to report on the Scope 3 impacts of their portfolios - including SMEs.

However, there are also promising *bottom-up* drivers of change, delivered through SME green nature-positive innovation and the early-stage impact investor (business angel, public and private VC and accelerator) requirements, derived from their attraction not only by the financial returns that emerging nature markets can offer but the nature-related dependencies of the economy on nature.

Cabbage White butterfly on purple top vervain (Amy Burnett)

Key Findings and Recommendations: seven steps to developing nature-positive finance through SME innovation

Environmental nature-positive measuring and reporting

1: Environmental reporting regulations are the most important driver on UK finance markets, but they do not directly impact on the early-stage green innovation finance market.

Recommendation: All public funding (including early-stage innovation) should have a mandatory low-carbon impact reporting requirement and work towards establishing a nature-positive reporting framework. This will help with improving the alignment of the UK emerging green finance escalator, ensuring that early-stage green innovators are prepared to meet the reporting demands of later stage investors.

2: Science-Based Targets (SBTs) are required for nature-positive reporting to operate effectively within the finance market. The Science-Based Target Network's 2023 release of initial nature targets addresses key drivers of biodiversity loss through freshwater and land metrics, yet comprehensive biodiversity state-based targets remain in development, reinforcing the need for accessible measurement technologies that support SME inclusion whilst frameworks continue to evolve.

Recommendation: Enhance existing public research funding to support development and adoption of nature-positive measurement solutions such as eDNA, satellite, visual, audio and sensor measurement by SMEs, which can offer biodiversity or suitable land and water quality proxy measurements. For instance: (1) making these innovations affordable and accessible for SME adoption; (2) supporting collaborative measurement approaches that distribute costs across multiple smaller businesses; and (3) providing capacity-building alongside technology access. This includes supporting communities and other stakeholders to support this work at scale through integrated approaches and governance (i.e. citizen science). However, this must not exacerbate the existing plethora of metrics and an urgent convergence of frameworks and their interoperability is required, especially where this supports the inclusion of SMEs in their reporting.

3: Innovation in nature-tech is ahead of policy, but it requires stable policy and regulation to assist market adoption with natural biodiversity ecosystem-related impact measures. Biodiversity Net Gain (BNG) provides an initial formal approach to create a market mechanism through nature-positive reporting (through its operation in the planning system), but it is only a proxy habitat measure for biodiversity (i.e. rather than delivering species performance measures). It is vital that nature-tech offers practical and accessible measures for SMEs.

Recommendation: Beyond the planning system, subsidise pilot measurement studies in different industry sectors, such as farming where there is often not the profit margin to pay (costly) experimental services. Regulations should be regularly updated in this rapidly progressing tech-driven market, based on sufficient pilot evidence – suggesting a need for more reflexive approaches to regulation and policy-making, especially in planning systems. Natural (and related social) ecosystem impacts should also be considered at scale.

Delivering an effective green nature-positive SME innovation finance market

4: The evolving UK green finance escalator (the mechanism to support early-stage companies to grow and scale) is complex, often fragmented and siloed, particularly around developing coordinated approaches to nature-positive enterprise.

Recommendation: Extend business support to include a more holistic approach to venture development, which can involve open research collaboration and the ability to (i) match research to industry innovation requirements and (ii) new venture services together through the stages of their development (particularly where this leverages advancement in platform governance and AI-driven insights).

5: The linkages between the different stages of the UK publicly-funded green finance escalator remain complex and disconnected.

Recommendation: As per the Willow Review (Stace and Ovens, 2025) comprehensive recommendations to UK government, develop a transparent holistic SME green innovation finance roadmap that strategically brings together appropriate government funding agencies to ensure that high priority cleantech (focusing on net-zero) also considers 30 by 30 biodiversity targets. This may include prioritising the most promising cleantech for large-scale state support, as in the case of France's 'Tech Green20' programme. This can leverage start-up innovation into the coordinated, mission-led approach to supporting SMEs (and Voluntary, Community and Social Enterprises (VCSEs) into green innovation procurement opportunities through the emerging new procurement regime under the 2023 Procurement Act.

6: Early-stage private environmental impact investment by business angels and seed venture capital firms[2] is currently primarily motivated by the personal values of individual investors and fund managers.

Recommendation: Enhance government support for early-stage green investment through an expanded direct stimulus via the Enterprise Investment Scheme (EIS). This enhanced scheme should not only support green innovation but also provide longer investment horizons with improved tax relief terms for investments held for at least five years (rather than the current three years), particularly where they demonstrate added environmental and social benefits.

7: Intermediary services provide important frameworks for measuring environmental impact and act as conduits for bringing together public and private finance to green nature-positive early-stage innovators.

Recommendation: Provide targeted national green funding streams to local authorities (e.g. through the (now reduced) Shared Prosperity Fund and place-based initiatives) that enable them to establish green innovation support hubs. This could be complemented by guidance to manage localised nature-based schemes that support nature-positive business support schemes and public green infrastructure projects, especially in the context of potential innovation that can be supported under a move to widen devolution. This should involve SMEs (especially early-stage innovators) and community-based nature-positive innovators as co-designers in such schemes to leverage and extend nature markets beyond statutory markets, such as BNG.

2 i.e. VCs that invest during prototype/proof-of-concept rather than revenue-generating or scaling phase.

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For a detailed summary of relevant definitions and terms affecting SME-Nature Positive Finance, please refer to our project **Glossary** *(Annex 1). For relevant mechanisms and policies affecting nature investment and early-stage enterprise, please refer to the* **Mechanisms and Policies** *(Annex 2). Both are available on our project webpage.*

Introduction

What is SME nature-positive finance?

The green economy embodies all kinds of business operations that actively seek to reduce environmental impacts and address global climate and biodiversity challenges. There has been an increasing effort to integrate nature into global efforts to encourage a more 'nature-positive' future, demonstrated by the UN International Day for Biological Diversity (IDBD) on 22nd May to increase understanding and awareness of biodiversity issues. The UN '30 by 30' Kunming-Montreal agreement in 2022 to protect 30% of global land and water for biodiversity by 2030, marked a significant global commitment to encourage biodiversity protection and related investment.

However, the role of Small and Medium-sized Enterprises (SMEs) is an important and frequently overlooked part of the green economy (Owen et al., 2023) SMEs are critical for two fundamental reasons: first, they represent a large part of the overall economy – in 2024 UK SMEs (5.45 million) represented 99.2% of the private sector business population, 60% of employment and 52% of turnover (FSB, 2024), as well as contributing to half of private business greenhouse gas emissions (British Business Bank, 2021). Secondly, SMEs are agile innovators and drivers of economic growth (Lerner, 2010; Brown et al., 2014). Therefore SMEs, if supported by public policy and the right investment landscape, can help to develop the UK's green economy and deliver the clean energy sector growth as set out in the UK government's updated Industrial strategy (DBT, 2024).

This paper focuses on the role of UK SME green innovation to deliver nature-positive outcomes.

SMEs are a heterogenous group of businesses defined in the UK as having less than 250 employees[3]. Green SME innovators, fall under the domain of 'greentech' enterprises (Mukherjee et al., 2024), described by the European Union (EU) green taxonomy as companies offering:

> *"…an innovative solution (a product, a service or a process) that improves the environmental impact of companies or end consumers, by significantly contributing to at least one objective of the European [green] taxonomy: climate change mitigation, adaptation to climate change, sustainable use and protection of aquatic and marine resources, transition to a circular economy, pollution prevention and reduction, protection and restoration of biodiversity and ecosystems."*

Thus, within the context of this report, SME nature-positive finance can be best described as finance that supports SMEs to improve the status of biodiversity and environmental ecosystems. As such, it is necessarily interconnected to the more mainstream 'cleantech' climate and clean energy sector (Gaddy et al., 2017) but grounded on Dasgupta's (2021) vision of all business activity being centred upon doing environmental good and improving the global environment.

This paper adopts an entrepreneurial finance ('entfin') theoretical approach that distinguishes between two categories of SMEs: (i) start-up and early-stage 'innovators'; and (ii) established SME innovation 'adopters'. This approach demonstrates that these two categories require different types of finance in relation to their maturity status along the stages of the finance escalator (see *Figure 1*), which follows the stages of business development from an initial concept idea, through start-up and commercial scaleup to established maturity (BEIS, 2017; Owen et al., 2019).

3 For the government definition of an SME see Government Commercial Function, 2024.

What are the main constraints facing early-stage SMEs in accessing green finance?

As Villena and Dhanorkar (2020) indicate, supply change pressures arise through a combination of factors: *coercive* (regulatory or conforming) pressures come from buyers/customers; *mimetic* (copying) pressures from competitors; whilst *normative* pressures come from requirements for market legitimacy.

Recent studies (Owen et al., 2022; Gottschalk and Owen, 2023; Cowling and Liu, 2023) find that established SMEs are heavily influenced and reliant upon government grants and subsidies to persuade them to invest in green infrastructure, equipment and practices. They are also influenced by regulations and reporting standards imposed by larger business and organisational supply chain buyers[4]. For instance, any bidder for major UK public contracts needs to demonstrate net-zero action. More recently, with the introduction of the Procurement Act 2023, there will also be an increasing shift towards supporting SMEs and VCSEs into public sector supply chains, posing opportunities to position early-stage SMEs into inclusive and potentially regenerative supply chains (Burnett, 2022).

However, there remain challenges in terms of SME supply side engagement on public green finance and investment. Findings from the Department for Business and Trade (DBT) Small Business Survey data (Owen et al., 2022) and the British Business Bank (2021) suggest that while SME knowledge about net-zero has been increasing in recent years, investment in terms of take-up of government programmes and support has not increased. This is partly due to lack of investment appetite in the current economic climate (which has seen energy and food inflation and resultant higher costs of borrowing) and concerns about financial returns on investment, particularly amongst potential early innovation adopters facing environmental policy and regulatory uncertainty (Uyarra et al., 2016; Owen, 2021), such as the delay in introducing UK Biodiversity Net Gain (BNG) to planning, the Government withdrawal of its £28bn environmental investment pledge in 2024 and the withdrawal of the Sustainable Farming Incentive scheme in 2025 (Gottschalk et al., 2024; Case, 2025).

On the supply side, a further concern is that SMEs failing to adequately assess and address sustainability to meet more stringent corporate standards also run the risk of becoming reputational and compliance liabilities in their supply chain. While on the demand side, there are signs that sustainability and net-zero commitments are going backwards. For instance, there is a worrying trend of asset managers voting against biodiversity proposals (Mace, 2024), corporates and local authorities "greenhushing" sustainability progress in fear of challenge and reprisal from critics and some investors are withdrawing their support for Science-Based Targets Initiative (SBTs) – in part due to pressure from the US on anti-trust concerns (The Insurer, 2025). Many governments (including in the US and Europe) are doubling down on national economic growth and productivity targets, to the detriment of climate and biodiversity commitments.

Policy drivers are increasing pressure on larger companies to consider and measure their nature-related impacts. This is driven by a combination of increasing environmental reporting disclosure requirements (e.g. the EU's Financial Disclosure Regulation and the UK Sustainable Disclosure Regulation) and through longer horizon investors and shareholders (e.g. pension funds, insurers,

4 Developing London's SME Green Business Transition: Finance and Support Services London Councils report (2025).

investment banks) concerned about financial risk assessment of potential stranded assets, mounting reparation costs and reputational damage (F4B 2022a, b).

The Kunming-Montreal Global Biodiversity Framework (2022) requires mobilising at least $200 billion annually in additional biodiversity finance by 2030, whilst reducing $500 billion in harmful subsidies. Science-based targets and nature-related financial disclosure frameworks like TNFD help financial institutions align their portfolios with these goals.

Voluntary frameworks including TNFD and the Science Based Targets initiative (SBTI) enable organisations to assess, manage and disclose biodiversity and climate-related impacts. As adoption increases among large corporations and financial institutions, reporting expectations will cascade through supply chains to SMEs and smaller market participants. This presents resourcing challenges for organisations with limited capacity to collect and verify environmental data. The development of the UK Sustainability Disclosure Standards and ongoing TNFD guidance should therefore prioritise proportionate, scalable approaches to SME reporting, developed in close consultation with government and business representatives.

Summary contribution of this report

This report focuses on the SME early-stage green innovation finance available in the newly emerging UK green finance start-up escalator (Owen et al., 2018) and specifically addresses **how to measure and report green financial risk and mitigation impacts.** We aim to understand how green impact financiers screen and monitor their portfolios to select and ensure that they are making a net positive environmental contribution, focusing on the following two research questions:

- **How to measure and report green nature positive inclusive financial risk and mitigation impacts?**
- **How to deliver an effective green nature positive inclusive SME innovation finance market?**

Focusing on early-stage nature-positive UK SME innovations, we outline the specific drivers, pressures, status, impacts and responses (DPSIR) to assessing, reporting and investing in environmental impacts in SME green innovators that make a positive change to the environment (Gao et al., 2018). This spotlight offers insights into both how these businesses are financed and also how their innovations can assist in the measurement of environment and biodiversity impact and establish financial value to them. This can help achieve the objective of TNFD (2021) and Central Bankers (NGFS, 2022) to enable financial market risk assessment for commercial biodiversity impact through science-based targets (SBTs).

Below, we set out our methodological approach, followed by a literature and data review (Part 1) and the findings from our qualitative fieldwork study (2022-25) and a set of conclusions and policy and practice recommendations (Part 2). Our report also showcases case studies of early-stage SME innovators that are developing global-leading ecological technology measurement services, and the role they play in shifting the dial on effective measurement and reporting in the emerging nature-positive innovation finance regime.

Methodological Approach

A qualitative evidence-based approach was adopted (Cresswell, 2003). We followed an abductive approach (Gioia et al., 2020), developing a research framework reflecting the entfin ecosystem literature, which informed the required interviewee types and thematic questions.

Step 1 - a review of current SME 'entfin' (entrepreneurial finance) literature and the limited available UK secondary data relating to SME environmental investment (e.g. the Longitudinal Small Business Survey (LSBS) waves data, 2017-2022; Gottschalk and Owen, 2023).

Step 2 - Qualitative data was collected via interviews, undertaken online. Interview evidence was recorded (where permitted), transcribed, fact-checked by participants and triangulated with other evidence, such as online publications and organisational websites. Following Harrer and Owen's (2022) approach, we sought a broad base of purposively selected evidence from across the entfin early-stage innovation finance ecosystem 'triple nexus' intersection of green financing activity (see also F4B, 2022a; UNEP-WCMC, & F4B, 2022). This required focusing the research on the determinants of external financing for green innovation SMEs from the perspectives of founders, private and public investors and related support organisations. This included: (i) 10 case studies of green innovation entrepreneurs, (ii) 43 financiers from the public (7) and private sectors (36) and (iii) 25 related intermediary support infrastructure services (18) and related private sector larger supply-chain businesses (7) (see Table 1). Many participants were interviewed at least twice, providing longitudinal insights into the developmental processes taking place (Owen et al., 2019c)[5].

Key Informant Type	No.
Finance Supply	N=43
Venture Studios/incubators	7
Accelerators	3
Business Angels	7
Seed/VC	10
Green Banks	3
Banks	6
Public funds	7
Intermediary Market Supporters	N=35
Trade Associations	6
Accountants	6
Consultants	6
Enterprise Agencies	1
Public Agencies	9
Large Businesses supply-chain finance and reporting	7
Venture Demand	N=10
SME ecological services start-up innovators	10
Large Businesses	7

Table 1 | Types of Enterprise, Financiers and Support Organisations Interviewed (N=88, 2022-25)

5 Appendix 1 provides a full description of the methodological approach and table of interviewees by category.

Informed by the literature review and overriding research questions, the interviews explored the following topics through semi-structured questions (Kintzer, 1977):

- actor and organisational profile
- respondent understanding of UK green investment markets
- actions taken to overcome information asymmetries (relating to developing environmental impact assessments and screening and monitoring investments and lending portfolios)
- learning interactions between actors across domains to understand what works; the role of intermediary support actors
- the role of public policy regulations and financial support proposals for improving the operation of the SME green finance market in the UK.

Step 3 - Qualitative data was systematically analysed and inductively coded into key emerging themes which were determined by repetition and strength of interviewee conviction (e.g. Green Angel Syndicate, who represent over 300 UK impact investors, state that carbon reduction is their main impact investment measure) and triangulation data. Emerging themes, relating to the dynamic factors (which can be related to TNFD Locate, Evaluate, Assess and Prepare (LEAP) and our DPSIR guidance – see below) affecting the market and approaches to impact investment assessment were coded and form the structural basis for the findings (Harrer and Owen, 2022).

Utilising a DPSIR/LEAP framework

A major challenge for businesses is to understand their impacts on the environment, particularly in relation to biodiversity (DEFRA, 2022). Often the impacts of business models are not directly evident, due to the difficulty in seeing and establishing a causal relationship between the business activity and its supply chains and impacts on nature and the environment. In this study we draw upon two complementary approaches that help to establish business environmental impact causal linkages. Essentially these approaches present a structured awareness raising, mitigation and reporting process by which all businesses can continually learn and progress towards net-zero and nature-positive business models.

The TNFD (2021) adopted a version of LEAP, which relates to locating business interface with nature, evaluating impacts and dependencies, assessing risks and opportunities and preparing responses and reporting. This has shaped powerful guidance tools such as Deloitte's LEAP Dashboard and guidance which can score business dependencies on environmental material factors (e.g. air, water) and environmental risk hazard factors. However, establishing the causal links between business pollution and mitigation practices and biodiversity are arguably better serviced by a more nuanced framework. This analytical strand of our work was led by researchers at the University of Reading who developed a multi-sector DPSIR framework that assesses drivers (business activities), pressures (pollution and material use), current status, environmental impact and response action planning (*Figure 1*). When reviewed together, these can offer a powerful lens through which to monitor changes and offer a continuous improvement loop for SMEs and their financiers to understand their nature-investment dependencies.

With regard to SME green innovations, the DPSIR model is particularly helpful in specifying the linkages between the innovation and impact changes to the sector baseline of impact. For example, the model helps to articulate how collaborations between stakeholders (e.g. across the

green innovation supply chain) can make a nature positive difference, such as Nature Metrics introducing eDNA testing on land regeneration schemes by industry.

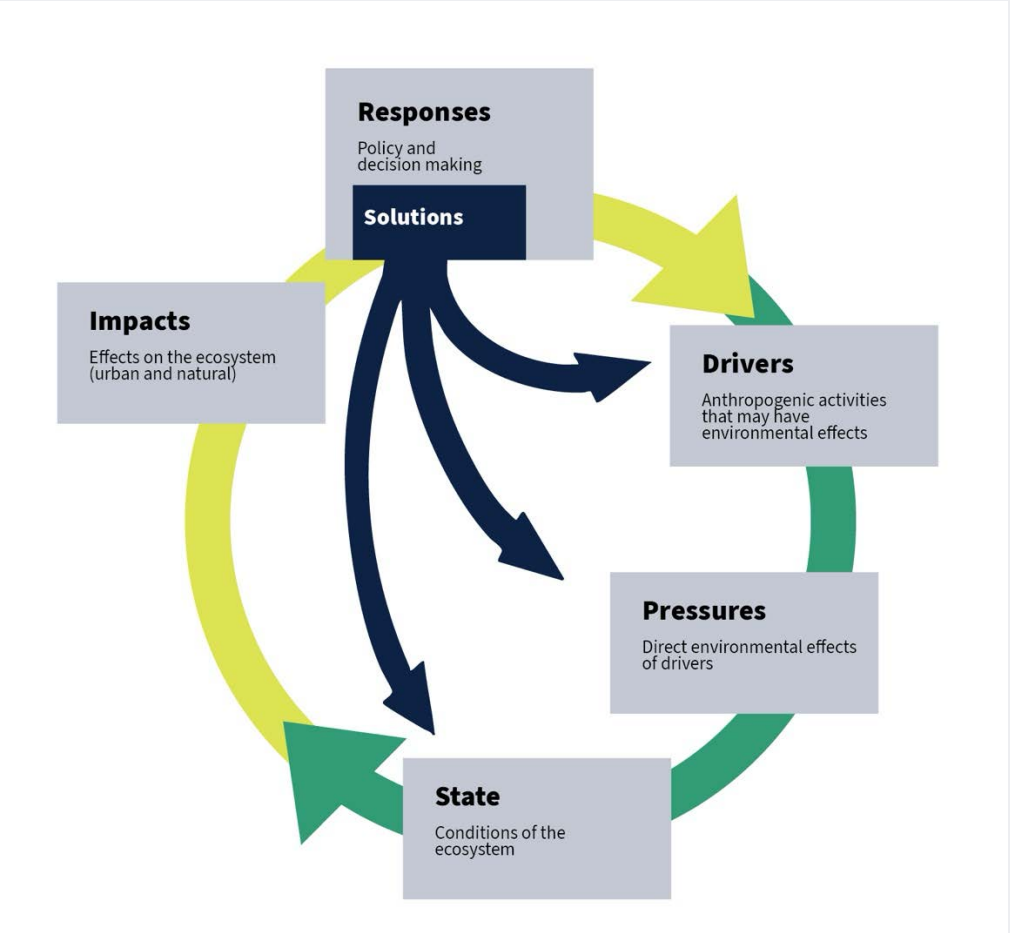

Figure 1 | DPSIR Model. Source : Encyclopaedia MDPI (modified)

Part 1: Review of Literature and Secondary Data

In Part 1, we present a short review of current academic and secondary practitioner literature on UK SME green finance and innovation relating to climate, sustainability, nature-positive, regenerative and circular economy business practices. In particular, we explore why 'nature-positive' could help frame action to respond to the UK's contribution to a global environmental crisis and the critical role that ecological services can play in mobilising the investment required to meet climate and biodiversity goals.

The Nature Positive Initiative (2023, p1) defined 'nature positive' as a global goal, building on the work of Locke et al. (2021), aligned to the 2022 Kunming-Montreal agreement to "*Halt and Reverse Nature Loss by 2030 and achieve full recovery by 2050.*" It was adopted by governments, including the UK, as a basic principle for inclusion in corporate environmental, social and governance (ESG) reporting, with emphasis on companies and financial institutions to locate, evaluate, assess, prepare (LEAP, TNFD, 2022) to report their nature-related material impact. However, the term has been criticised for its vagueness and lack of established science-based targets (SBTs). To this end the TNFD (amongst others like ENCORE and Wallacea) have worked globally to establish definitions of nature metrics and their positive outcomes. There is a growing recognition (NGFS, 2022) that advanced technological measurements such as eDNA and Internet-of-Things (IoT) sensors, aligned to AI may hold the key to establishing credible SBTs to guide the financial markets.

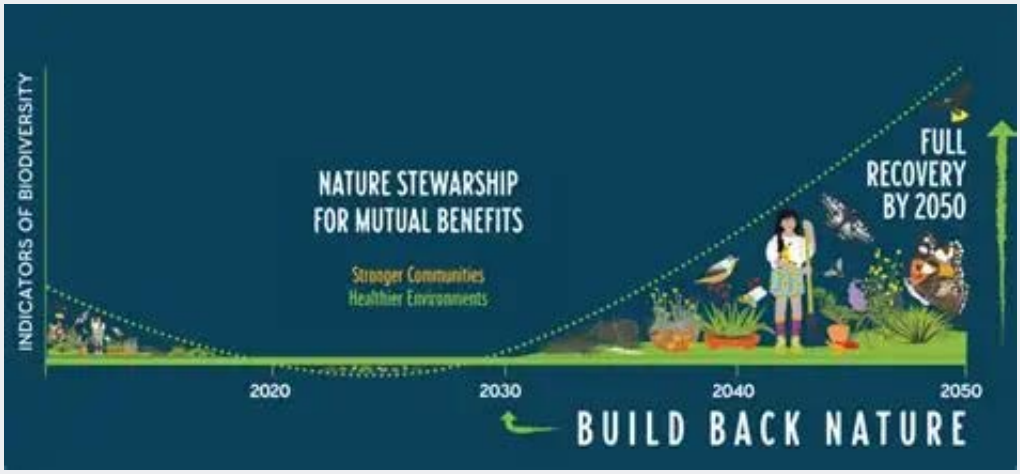

Figure 2 | Nature Positive Progress (conservationvolunteers.com.au)

UK SME green innovation and the key role of ecological services

SME green finance is a nascent field of research. Relatively little has been published on early-stage green innovation finance within the UK context. Mukherjee et al., (2024) explore the evolution of global SME green finance markets, revealing they are nascent, requiring further data and more incisive mixed methods research. Owen et al. (2022) found limited understanding of the

overall operation of the UK early-stage green innovation impact investment market. This is due to a combination of factors, including:

- Lack of national data (Owen et al. 2020a)
- Lack of a coherent integrated national policy (Owen, 2023) – with no clearly defined SME green innovation finance roadmap in national strategy (HMG, 2023)
- Lack of qualitative studies offering an understanding of what an integrated climate and nature-positive innovation finance market means in terms of environmental impact assessment (Owen et al. 2023).

Whilst this report addresses all three obstacles, we focus on developing qualitative understanding, to address the fundamental question posed by TNFD (2021) and the Central Bankers (NGFS, 2022) of how do we measure and report green financial risk and mitigation impacts?

Following the UK's hosting of COP26 in Glasgow in November 2021, there has been increasing UK adoption of low-carbon measurement and circular economy practices by larger businesses engaged in environmental, social and governance (ESG) reporting. This has been driven by climate reporting regulations that came into force on 6 April 2022, requiring companies with over 500 employees and £500 million annual turnover to make TCFD-aligned disclosures. However, with approximately 1,300 companies in scope, this directly impacts less than 0.1% of UK businesses, leaving most SMEs currently outside mandatory reporting requirements. Since then, the UK is developing the UK Sustainability Disclosure Standards (UK SDS). The government is considering whether to extend disclosure requirements to large private companies not currently in scope, with decisions expected in 2025 and any new requirements unlikely before 2026. However, no definitive arrangements for broader SME reporting requirements have been agreed.

Leaving action to SMEs without regulatory underpinnings could be problematic to achieve UK economy-wide action. Taking the example of net-zero, the annual UK LSBS data demonstrates rising awareness by SMEs of government climate programmes, but concerningly limited adoption (Gottschalk and Owen, 2023). Fundamentally, SMEs have little knowledge of their wider environmental impacts, including their Scope 2 energy sources and Scope 3 supply chain influence (see *Figure 3* below).

They also have little appetite for investing in voluntary environmental mitigation (e.g. direct greening company premises and land, or opting into offsetting arrangements like tree planting for staff commuting carbon count), which often offers no clear bottom line business financial gain (BBB, 2021), particularly when they are facing a barrage of economic crises ranging from the collapse of international trade through UK exit from the European Union, the aftermath of the COVID-19 pandemic and the uncertainties of the Ukraine and Middle East conflicts which have led to higher levels of inflation, higher costs of borrowing and reduced levels of private investment (BBB, Equity Tracker, 2023). More recently the unexpected trade wars with the US have added further uncertainty to financial markets.

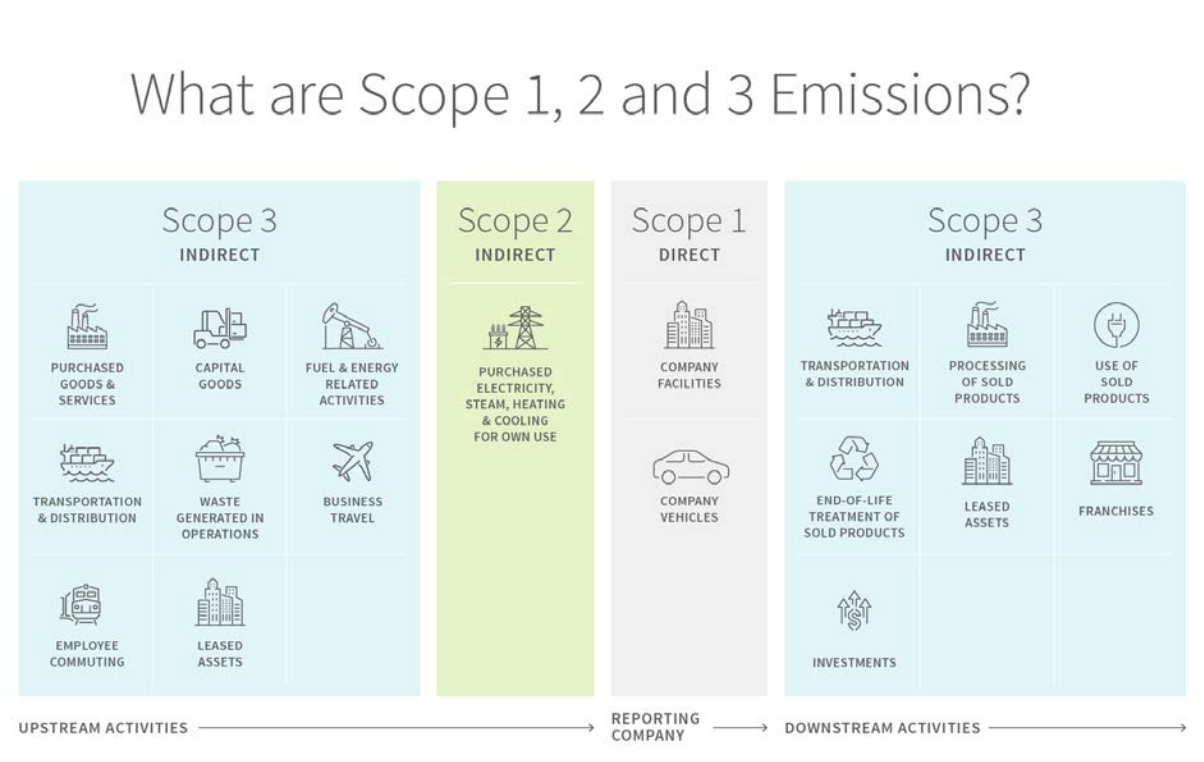

Figure 3 | Scope Emissions (Foresight)

In the face of such challenges, UK SMEs remain highly innovative and nimble, with a wide range of environmental innovation taking place, which is progressing beyond low-carbon towards circular economy considerations and addressing biodiversity and nature-positive actions (Owen and Vedanthachari, 2023). This involves actions within sector-based business models that include efficiencies to reduce material and energy use whilst also reducing pollution and environmental degradation. For example, innovative UK SMEs like Oxwash and Zedify have introduced green low-carbon transportation (e.g. e-bikes) and light vehicle final mile logistics to their operations, which include missions to reduce pollution and monitor the environmental impacts of their operations. Oxwash, for example, filters micro plastics from water recycled from their commercial laundry operations.

Critically, as Owen et al (2023) observe, SME innovators also include leading-edge approaches to biodiversity measurement, such as Nature Metrics' eDNA soil and water testing. This has potential (if affordable) to enable a wider range of environmental measurement of biodiversity which is accessible to all forms of business, large and small, across a wide range of sectors. These ecological measurement services (herein referred to as '*ecological services*') form part of the developing 'ecosystem services' sector globally and hold an important key for the SME finance sector to underpin evidence of the environmental impacts of investment. These initiatives are starting to mainstream the understanding of environmental impacts and embed science-based targets (SBTs[6]) into UK SME supply chains. The aim of the Central Bankers (NGFS, 2022) and TNFD

6 SBTs are greenhouse gas emission reduction targets set by companies based on the goal to reduce emissions to below 2 degrees C as set out in the 2015 Paris Agreement.

(2023) is for SBTs to extend beyond carbon measurement to include biodiversity metrics. The introduction of BNG into the UK planning system may be seen as a first step by creating SBTs for land development, by adopting habitat quality and type as a proxy for more complex biodiversity measurement. In the future, SME ecological services innovations such as eDNA may make this possible.

The UK SME Innovation Finance Escalator

The finance escalator provides a venture start-up and development stages structure for the supply of external business finance for a specific location and time (North et al., 2013). There is an acknowledgement that the escalator is dynamic, changing over time, according to economic cycles (Lee et al., 2015) and innovations in the finance markets (Baldock and Mason, 2015). Mason (2017) and Owen et al. (2019c) point to the expanding range of entrepreneurial finance supply in the UK funding escalator, since the global financial crisis (2007-08). This includes a progression from traditional bank debt and formal equity from venture capitalists (VC) to the growing formalisation of business angel investment through organised networks (e.g. Green Angel Syndicate (GAS), Seedtribe women angels and regional or local groups like Minerva in English Midlands, London, Manchester and Cambridge), forms of crowdfunding (equity, donation, reward and peer-to-peer lending) and a growing role for alternative smaller 'challenger' and impact banks, such as Monzo, Starling and Triodos (BBB, Equity Small Business Equity Tracker, 2023).

Accelerators, Venture Studios, Angels Networks and Seed VC

Within the early seed to Series A (pre-revenue to early revenue) stages, Owen et al., (2023a) point to recent trends for angel networks to develop Enterprise Investment Scheme (EIS) funds where investors are eligible for tax breaks on up to £1m annually. These EIS funds (e.g. GAS EIS Climate Change Fund) operate with Financial Conduct Authority (FCA) approval as small-scale angel-led evergreen revolving VC-like funds, that fundraise annually from angel networks and other external investors, such as family offices and VC. This expansion of angel network investment is allowing angels to follow-on investment into later deals.

Conversely, there has been a growing trend for VC and other types of investors (public and corporate VC) to invest earlier into seed-stage ventures and accelerators. Accelerators (e.g. Carbon 13) offer intensive support to cohorts of early-stage venture management teams, often investing small amounts initially with follow-on funding for the more successful venture cases that progress through the support stage (Pierrakis and Owen, 2022).

More recently, the 2020s has seen the rise of venture builder studios (e.g. Zinc) that seek to bring together pre-start and very early-stage entrepreneurial concepts to facilitate their networking and formation into commercial ventures that are aligned to solving real world problems and therefore have a good commercial market fit. Whilst accelerators are typically private and corporate funded, launchpads and venture builders have also attracted public funding, such as through universities and government-supported Catapults.

Owen and Vedanthachari (2023) note that critics of this 'lean venture launchpad' approach are concerned that these are often better aligned to software development, rather than the deep pocket hardware development that disruptive highly innovative deeptech requires. However, venture studios that closely align with corporate longer-horizon investors (e.g. new emerging

technologies, such as greentech), a potential financing model of progression that is like more established biopharma markets (Harrer and Owen, 2022). The UK Connected Places Catapults provides an example of a later-stage scale-up venture builder which brings together existing low-carbon ventures to tech stack and form new scalable ventures that will attract impact investment.

Government Grants, Tax Incentives and Co-Funding

Additionally, the UK government plays an important role by providing technology innovation and adoption grants, notably through Innovate UK's (IUK) proof of concept and 'Smart' awards for tech development and R&D tax breaks (BEIS, 2017; Owen et al., 2019). There are also grants, subsidies and tax breaks that can cover energy efficiency equipment adoption in relation to the UK Government's Energy Technology List (ETL) (BEIS, 2020; Owen et al., 2021). However, it should be noted that generic UK investment support through S/EIS[7] and R&D tax credits does not offer any specific incentive advantages for green investment.

Owen et al., (2020b) find few papers that focus on SME low-carbon and environmental finance markets. The emerging global entrepreneurial green finance literature tends to examine the role of public policy (Owen et al., 2018; Polzin, 2017, Polzin and Sanders, 2020; Mazzucato and Semieniuk, 2018) in more mature economy finance markets and how they address SME financing gaps for green, ecological innovation. Public policy interventions typically operate through co-financing programmes that seek to reduce the information asymmetries and private sector investment risks, which prevent early-stage innovation investment and subsequent market development (Harrer and Owen 2022).

Finance Escalator Stages and Green Impact Finance Availability

Owen et al., (2019) summarise the UK finance escalator (see *Figure 4*) in a traditional stages model, which draws from Burger and Udell's (1998) theory of the decreasing opacity of innovative potential high-growth entrepreneurial ventures. This progresses from higher-risk, earlier seed and start-up stages to commercialisation and later lower-risk scale-up stages and established market status. The finance escalator demonstrates that as ventures develop from R&D to commercialisation, the opacity and information asymmetries that exist between the entrepreneurs and potential financiers reduce (Carpenter and Petersen, 2002), enabling greater range of types of private finance and larger amounts of finance to be accessed.

A further observation is that government finance programme interventions are more common at earlier stages to fill the funding gaps where viable venture cases are unable to access private investment (North et al., 2013).

Figure 4 also demonstrates that public targeted green finance programmes are more likely to feature in earlier stage financing, with many post-Series A government funds operating through British Business Bank (including related Patient Capital Fund and British Business Investment programmes) remaining sector agnostic (Owen, 2023).

As North et al., (2013) and Baldock and Mason (2015) suggest, the funding escalator provides a dynamic model of funding - which changes over time and place - can demonstrate the allocation of public and private finance and the stages where public funding interventions can facilitate the more fluent process of innovation funding. Owen et al., (2019a) find that the journey of UK

7 The early start-up EIS investor UK tax break programme is called the Seed EIS ('SEIS')

innovative businesses to funding is varied and often discontinuous and may involve many years and funding rounds of development through to established commercialisation. Thus, early venture funding is risky and Markovitz (1952) VC investment pareto principles apply, whereby there is an uneven performance of start-ups with few (c.10%) succeeding and therefore making a return for investors; with plum (ripe) high multiple return investments often taking longest (i.e. 10-years plus) (Wiltbank, 2005). The route to maturity along the finance escalator is indicated below, where investors often spread their investments to mitigate risk. However, as our research illustrates the extent to which biodiversity is considered by investors in such risk assessments is even.

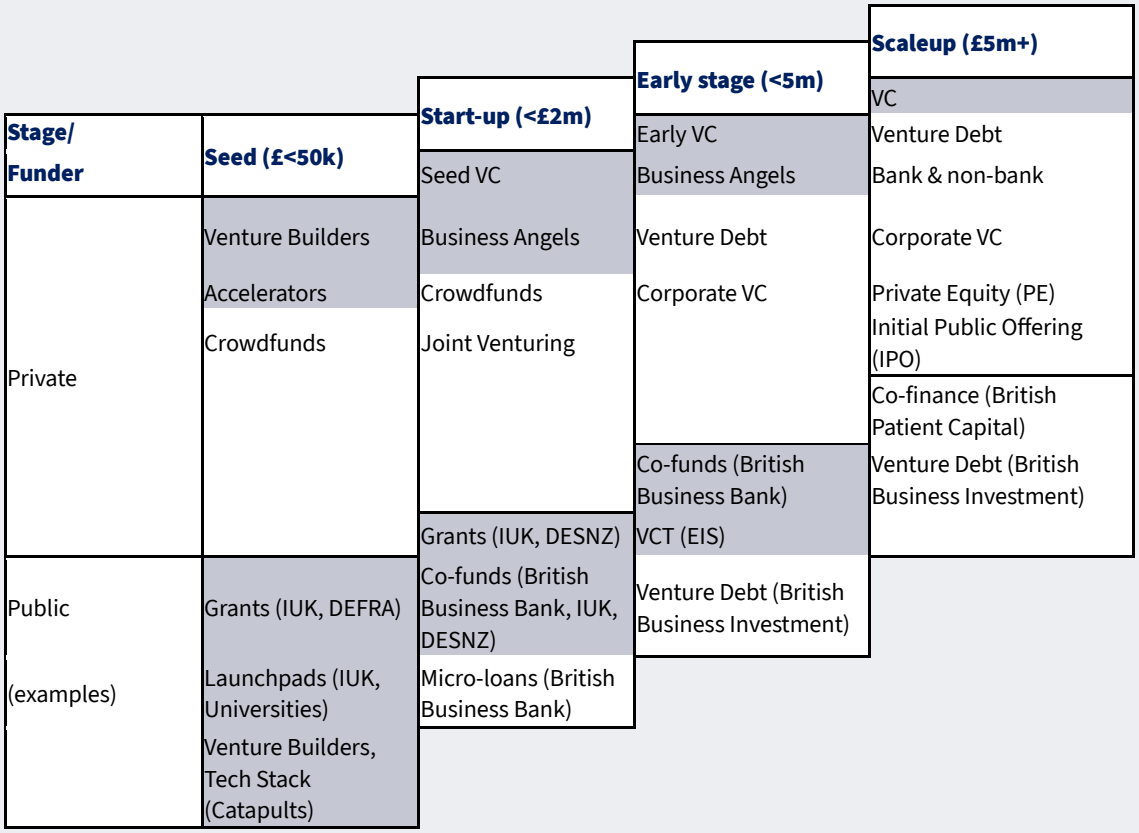

Figure 4 | Contemporary Early-stages UK Green Finance Escalator

Note: Types of (formal) funder providing targeted green finance marked in grey. DESNZ (Department for Energy Security and Net Zero); DEFRA (Department for Environment, Food and Rural Affairs); IPO (initial public offering); PE (private equity institutions and Family Offices); Non-Bank (alternative to traditional bank debt finance).

The size of the UK SME green-tech investment market

Evidence comes from four years of fieldwork (2022-25), initially involving a mapping of key investment actors in the UK SME green investment market, updating Owen et al., (2019b, 2020) by focusing on the earlier stages of SME innovation financing. This builds on the secondary source UK data provided by Beauhurst, which is narrowly defined to cleantech energy and low-carbon venture investment. Contextually, whilst there is no published data for annual UK green investment per se, Beauhurst (2022) calculated that the formal disclosed investment in UK cleantech was £945m from 168 round deals in 2021 (rising from £631m from 114 deals in 2020). These investment levels represent a considerable increase on the 2012-18 period where annual

investment ranged between £143m (2014, 62 deals) and £308m (2018, 88 deals). The recent trend has been for more deals and larger deal sizes. Overall, Owen et al. (2020) calculated from Beauhurst[8] data that the total size of the UK cleantech investment market from 2011 to the first quarter (Q1) 2020 was circa £4bn. According to the British Business Bank SME equity tracker (BBB, 2023) this had almost doubled to around £7bn by Q1 2023.

The most recent published UK paper (van der Schans et al., 2025) curates a bespoke calculation of UK 'greentech' innovation finance from Beauhurst data (2011-2024), which includes cleantech and additionally nature tech and circular economy technologies. This demonstrates average annual UK greentech investment of £2.2bn (326 annual investments) between 2021-2024. This equates to about one-eighth of all UK equity investment deals, of which three-fifths of greentech investments were into hardware tech. Van der Schans et al. (2025) also demonstrate that UK greentech hardware firms take longer (from company registration) to raise their first funding rounds and require larger first funding rounds than their non-greentech counterparts. Furthermore, the paper highlights underinvestment in UK greentech during later funding rounds when compared to their French, German and US counterparts. In summary, the UK greentech investment market has matured but still exhibits potential funding gaps holding back start-ups and scale-ups.

Our mapping also revealed a rapid rise in the presence of angel impact investors, specialist seed VCs and accelerator and venture studio activities. Between 2020-24 the numbers of green mission business angels in the UK within the two largest impact angel networks, Green Angel Syndicate (GAS), and combined Five-Thirteen/Seedtribe women's angel network, trebled to over 600 members. The British Business Bank equity tracker (BBB, 2023) also found a rise in Universities' spinout fundraising (£2bn in 2022, representing one eighth of the total UK SME investment market that year) spurred by a combination of emerging joint university VC funds (e.g. Northern Gritstone and Midlands Mindforge) and co-funded private VC through the expanded Science and Seed Fund (UKI2S), which focuses on university spinouts and cleantech. Whilst the data collected for this study cannot be claimed to be fully representative, our study interviewed investors from all these investor categories (see Appendix 1 methodology details).

The UK (and global) green innovation investment gap

The green investment gap occurs through a convergence of multiple issues that disrupt the operation of the standard finance escalator (Owen, 2023; Owen et al., 2023; Harrer and Owen, 2022). These issues create barriers to finance for earlier-stage SME green innovators (*Figure 5*).

First, there is simply the inability to overcome information asymmetries at earlier stages of innovation, which becomes exacerbated for green disruptive innovations that deliver new tech platforms (e.g. engineering biology) - which are often less understood by financiers (Owen and Vedanthachari, 2023; O'Reilly et al., 2023).

8 Beauhurst is the leading source of SME finance data in the UK, used by the British Business Bank annual UK Small Business Equity Tracker reporting. It tracks all formally disclosed UKRI grants (£100k plus) and venture investments from 2011, from start-up along the finance escalator progression stages. It includes a cleantech sector/vertical definition following MIT (Gaddy et al., 2017), which includes renewable energy and associated low carbon activity.

Second, SME entrepreneurs and their financiers do not know how to effectively signal environmental impact for investment screening and monitoring (Harrer and Owen, 2022).

Third, deeptech disincentives for external investors relate to long-horizon hardware R&D and lead to an extended and expensive capital investment requirement through the 'valley of death', prior to commercialisation and secure profitable income generation (Mazzucato and Semieniuk, 2018; O'Reilly et al., 2024). Deeptech requires substantial patient capital funding for post=revenue scale-up development of plants (Mazzucato and Penna, 2016), which UK (BBB, 2021) and European (Arundale, 2020) VCs typically do not have the investment capital and risk appetite to meet.

Fourth, there is no green dividend to encourage green impact investment, since public good spillovers (e.g. improved public health) are not repaid to the private investors (Polzin, 2017). Fifth, lack of market stability through economic cycles (Lee et al., 2015; Cowling and Liu, 2023). Sixth, poor policy mix (Uyarra et al., 2016) and a lack of consistent long-term environmental regulations and policy promote uncertainty and undermine market confidence. Finally, where public policy intervenes to finance SMEs, it is difficult to find and access, with no clear public finance roadmap to support SME green innovators (Owen at al., 2019a).

High levels of Information Asymmetries between SME demand and finance supply:

- Green innovation is disruptive and new – little understood (Owen and Vedanthachari, 2023; O'Reilly et al., 2023)
- Signalling of environmental impact is poor – particularly at early-stage (Harrer and Owen, 2022)
- Understanding of wider environmental/circular economy impact in investment screening is a concern (Owen, 2023)

Deeptech disincentives:

- Green innovation hardware is often highly capital intensive and long horizon (Mazzucato and Semieniuk, 2018; BBB 2021) – software tech is shorter term, more attractive, and supported by Seed/Enterprise Investment Scheme (Owen et al., 2019b)

Lack of green dividend:

- No public investment incentive to reimburse investors fully for societal benefit (Polzin, 2017)

Lack of market stability:

- Economic cycles impact green investment (Cowling and Lui, 2023; Owen et al., 2022)
- Government mixed messages, lack of green policy cohesion (Uyarra et al., 2016)
- Cohesive, clear, more decisive regulation required - coordinating environment with business and finance – bringing together key departments - DEFRA, DBT/Energy, Treasury (Owen, 2021)

Figure 5 | Key Components of the Green Innovation Financing Gap

The SME innovation adoption funding gap

Critically, the success of SME green innovation commercialisation is dependent upon market acceptance and adoption, including SMEs' ability to fund and adopt green innovations. However, recent UK SME surveys (discussed below) persistently demonstrate that SMEs and particularly smaller businesses, even when aware of environmental investment priorities, fail to act. This has been due to uncertainty over the value of investment, lack of information and guidance, limited perception of the environmental impact and therefore need for action by the business, and inability to act due to lack of capacity (time and resources, including access to finance) and rental constraints. In the current poor economic conditions, it is telling that less than one fifth of SMEs believed that environmental investments would improve their bottom-line economic performance (British Business Bank, 2025).

SQW's (2021) review of 13 UK SME low-carbon business support programmes found a crucial funding gap for established SMEs to adopt ecological processes and practices. This stems from the information asymmetries that exist due to an inability to calculate the financial value of ecological innovation adoption to the business model and ascribe sufficient financial remuneration to the business investor. Notably, there are unpaid spillover socio-environmental benefits, such as health and biodiversity improvements from reduced pollution. Thus, Polzin (2017) argues that governments should contribute to 'public good' funding programmes to remunerate and encourage environmentally positive businesses.

The British Business Bank's Small Business Finance 2024-25 report (2025) highlighted significant challenges for the UK economy, through the continuing global period of economic turbulence. 2024 saw only a small rise in GDP growth initially 0.9% and then revised to 1.1% (ONS, 2025) this was below that of G7 peers such as US (2.8%). A major feature of recent low UK economic growth has been the reduction in the numbers of SMEs undertaking investment, with little overall growth in real terms of aggregate SME investment. The proportion of SMEs prioritising sustainable investment for the next 12 months remains at just over half (53%, compared to 46% in 2022), with medium-sized enterprises (74%) and production activities (68%) more likely to prioritise environmental investment.

For those not prioritising environmental impact, this was typically due to a lack of ability to act (e.g. Gottschalk et al., 2024, found that many SMEs are in rented property where environmental actions are determined by landlords) or lack of appreciation of business environmental impact (e.g. in a perceived low environmental impact sector). For those with environmental investment priorities, two major barriers are economic and regulatory uncertainties, followed by typical time and resource issues that smaller businesses regularly state prevent investment (British Business Bank, 2025[9]).

A further critical issue revealed by the Small Business Survey (BBB, 2025) is that few UK SMEs (6%) currently measure or report their carbon impact. Whilst around one third report that there are no obstacles to carbon reporting, or that it is not relevant to their businesses, the remainder report at least one barrier, with the main barriers being lack of knowledge, capacity and advice.

9 Data provided by the British Business Bank Small Business Finance Survey, 2024 (n=1,547)

The need for universal science-based environmental impact measurements

Establishing a consistent, universal measuring framework is essential for the efficient operation of green finance markets (NGFS, 2021; TNFD, 2021; Harrer and Owen, 2022). Whilst Owen et al., (2020) and SQW (2021) demonstrate some convergence towards common low carbon measurement (e.g. *tCO2e* greenhouse gas reduction per production unit), they also found a proliferation of different carbon accounting standards (e.g. Global Impact Investment Rating System and Sustainable Accounting Standards Board) and carbon tracker tool approaches. There are also complexities in measuring 'Scope 3' impacts in the supply chain (Carbon Trust, 2022), circular economy and regenerative practices such as longevity, repair, repurposing and recyclability (Climate-KIC, 2022), whilst wider nature positive environmental impacts (e.g. the presence of pollinators) remain particularly difficult for investors to assess.

Financial subsidies and regulations signal market confidence

For early environmental innovation adopters, where information asymmetries preventing innovation market value assessment are highest, improved, standardised impact metrics, alongside financial incentives such as grants and tax break subsidies appear vital to reduce higher risk perception and encourage greater investment (Owen et al. 2022). Essential to this is improved policy coordination and monitoring (SQW, 2021) and a holistic, longer-term consideration to achieve a wider environmental nature positive policy mix (Owen et al., 2023; Uyarra et al., 2016).

Cowling and Liu's (2023) UK Small Business Survey data (2007-2012) study demonstrated that SME cleantech adopters had higher demand for external capital (than non-adopters). This demand was not fully met by bank debt finance and was significantly assisted by alternative government backed finance. Stable regulatory policies supporting SME green transition sent positive signals which reduced traditional market credit rationing (e.g. after the 2008 global financial crisis). Furthermore, higher-tech environmental innovators (achieving beyond government regulatory requirements) experienced a significantly more acute private finance gap from both debt and equity. These findings underline the role of environmental policy and regulations in signalling to private investment markets.

Cowling (2023) and Pierrakis and Owen (2022), also found that angel investors and accelerators are attracted by the certification effect of public grant funding for green innovation. Owen and Vedanthachari (2023) highlight the importance for university spinouts of supportive regulations for new frontier green tech (e.g. biofilm and engineering biology for water purification) to signal market stability and encourage financing, tech advancement and adoption. Cowling and Liu (2023) also suggest that grants for standard green technology adoption might lead to crowding out of the bank lending sector and might be better targeted at reducing the funding gap for higher-tech (higher risk) environmental innovation development and adoption.

Owen et al.'s (2022) more recent analysis of the UK LSBS (2019-2020) suggests that financial incentives can encourage SMEs' greater adoption of energy efficiency measures, particularly within the context of the economic constraints of the post-pandemic UK economy. Gottschalk et al. (2024) further demonstrate, using both LSBS survey and qualitative key informant financial intermediary interviews, that grant finance may be particularly effective in supporting smaller SMEs (notably micro employer businesses) that lack the resources and ability to access bank

loans. They find that small grants can unlock bank and alternative debt finance matching funding and facilitate green investment.[10]

The importance of policy mix and collective localism

Uyarra et al., (2016) highlight the importance of policy mix in their examination of UK low carbon enterprise innovation from an institutional and regulatory context. They found policy disconnect, notably in England's 'missing middle' of regional policy coherence, since the demise of the nine Regional Development Agencies in 2012. This led to the creation of 38 Local Enterprise Partnerships (LEP), which in turn was disbanded in 2023, in favour of a hybrid form of localism. This empowers local authorities to (voluntarily) form sub-regional coalitions to bid for local economy funds, such as through UK Shared Prosperity Funds (SPF).[11] However, this depends on the quality of partnerships and a competitive funding landscape often operating on an ad-hoc, project focused partnership arrangement.

Owen et al. (2021; 2023) also found fragmented coordination and limited organisational learning between key UK government departments (BEIS, DEFRA, HM Treasury) and their arms-length bodies, particularly the British Business Bank (the SME finance agency) and Innovate UK (the innovation funding agency under UKRI). This structural fragmentation resulted in environmental considerations being insufficiently integrated into mainstream business support programmes. Whilst both organisations had some environmental programmes pre-existing, the UK's hosting of COP26 in November 2021 acted as a catalyst for more explicit low-carbon focus. The British Business Bank's sustainability reporting strengthened from 2022, with increased tracking of cleantech investment. Similarly, Innovate UK launched its Launchpad programme in 2022-2023, which included agri-tech and food technology clusters with explicit environmental sustainability themes. However, the expansion of these programmes has been gradual, with further agri-tech Launchpads and funding rounds continuing through 2024-2025, suggesting ongoing rather than immediate policy integration.

Uyarra et al (2016) and Owen (2021) both find that the contemporary UK policy mix for low-carbon and environmental SME financing is poor and ineffective. Adopting Rogge and Schleich's (2018) policy level framework analysis, Owen (2021) demonstrates that it lacks; consistency (often being too short-term), credibility (putting efficiency before circularity), comprehensiveness (with insufficient funding scales), and coherence (there is no 'roadmap' to link green and sustainable finance with SME support services; Meissner and Kergroach, 2021). Indeed, the HM Government (2021) roadmap for sustainable finance[12] relates to COP26 and larger business climate impact reporting rather than SME support integration.

Whilst the subsequent Green Finance Strategy (HM Government, 2023) does at least introduce Biodiversity, it also only makes limited provision for SMEs with regard to consulting with the British Business Bank and creating guidance for net-zero reporting. Furthermore, whilst the British Business Bank provides an online finance finder platform for SMEs to explore all types of

10 This finding is also supported by unpublished reporting (2025) to the London Councils Green Economy Programme.
11 SPF provided £2.6b between 2022-25, replacing the place-based competitive European Regional Development Funds (ERDF)
12 The roadmap sets out the government's long-term ambition to make the UK "the best place in the world for green and sustainable investment" and to green the financial system and align it with the UK's net-zero commitment.

finance[13] (grants, debt and equity variants), as the Willow Report (2025) highlights, there is currently no comprehensive UK green SME innovation finance roadmap that consolidates the various available green finance options, regional schemes and sectoral support into a single, accessible pathway for smaller businesses seeking environmental innovation funding.

As we reflect on later, it is important to note that current measures being put in place to support the government's devolution agenda may enhance potential for localised partnership, or potentially compound issues of resource fragmentation.

The need for an SME green innovation overarching strategic body and finance roadmap

We conclude from these studies that UK green SME financing remains complex and confusing, with a frequently conflicting array of UK policy programmes and finance instruments that fail to effectively fill green tech finance gaps (Owen et al. 2019b; 2022; Owen, 2021). These issues reflect classic policy mix failures that send conflicting and often negative messages to SMEs considering investment priorities. Rating to for instance: the reduction of renewable energy feed-in tariffs in 2012; removal of enhanced capital allowance tax breaks for energy efficient equipment in 2020 (there is no specific green investment encouragement in the UK, apart from the 2022 VAT exemption for renewable energy equipment; MCA, 2022); and the delay to the roll out of Biodiversity Net Gain between Autumn 2023 to February 2024.

Many cleantech financing policies also fail to take a sufficiently 'deeptech', long horizon investment perspective, or account for 'regenerative' circular economy and biodiversity requirements, in their frequently short-term approaches to the UK's current 'Green Growth' strategy (Owen, 2021; SQW, 2021). This suggests that an overarching body such as the UK Green Finance Institute (established in 2019) could lead on providing a far greater, longer term, strategic overarching role in UK Cleantech innovation and adoption financing and address SME financing issues (Mazzucato and Penna, 2016; Owen, 2021). In this respect, the Government's (2021) green roadmap (and Green Finance Strategy, 2023) needs to go beyond green bond raising and large company ESG compliance to facilitate more effective SME green innovation and adoption.

13 https://www.british-business-bank.co.uk/finance-options/finance-finder

Part 2: Qualitative Fieldwork Study (2022-25)

We now present the findings from our qualitative longitudinal fieldwork study of SME green innovation finance stakeholders operating in the UK entrepreneurial finance ecosystem (2022-25) and 10 case studies of UK SME innovative nature positive ecological services start-ups (see Appendix 1 for further details). In doing so, we explore the financing experience of case study start-ups and highlight their role, through offering non-financial intermediary services, in solving the problems of measuring and monitoring nature positive environmental impacts and therefore assisting financial risk assessment of business activities.

Findings

Our research demonstrates that the UK early-stage green innovation market has evolved markedly since the UK hosted CoP26. This is taking place through public financing initiatives and the operation of the private sector, involving a growing and diverse range of financiers and related intermediary support services. From a VC ecosystem development perspective (Lerner, 2010; Owen and Mason, 2019) the alignment of these elements is crucial, since misalignments will cause blockages (e.g. to financing linkages and access to technical support service) in the evolving green finance escalator. Our findings highlight the primary requirement for nature-based SBTs to guide the nascent green impact investment market. We draw on the qualitative interview evidence (see Appendix Table A2) to highlight the key emerging themes which present barriers and opportunities for UK (and potentially global) green innovation market development.

The Evolving UK Green Finance Escalator

1. The increasing role of green impact finance in the public and private sector markets

The British Business Bank has increased measurement of its net- zero programme impacts, moving beyond the influence of the inherited European Regional Development Fund programmes (e.g. East of England Low Carbon Innovation Fund). Innovate UK (IUK) have expanded their support of low carbon infrastructure early innovation through the Investment Accelerator and subsequent Investor Partnership programmes, which now include impact investors (e.g. Green Angel Syndicate). In 2023, IUK has introduced a regional Launchpad programme encouraging low-carbon start-ups, which was expanded in 2024 to include agricultural technology ('agtech'). It is also supporting an increasing number of emerging private seed VC in the agtech and food production sectors through the Investor Partnership programme (e.g. Regenerate).

In 2021, the Department for Environment Food and Rural Affairs (DEFRA) launched the £10m Natural Environment Investment Readiness Fund (NEIRF), the first national habitat and biodiversity grant fund for nature-positive, early-stage innovators to help them prepare for private investment. This will feed into the Department's larger £30m UK Nature Impact Fund (2023) which seeks to blend public-private investment into nature positive projects[14]. The private sector has also seen increasing numbers of angel impact investors. For example, GAS, Seedtribe and Five-Thirteen impact angel networks reported that they had increased their membership threefold to

14 This fund designed and operated by Finance Earth is supported by DEFRA's UK Nature Accelerator technical assistance programme for nature-based solutions https://uknaturefund.com/accelerator/

over 600 members in the last three years. Additionally, there have been increasing numbers of specialist venture studios and accelerators (e.g. Carbon13 and Zinc) and seed VCs, including in agtech (e.g. TfT, Regenerate, Pelican).

2. The rise of impact venture studios

The private sector is leading on developing venture builder studios, typically funded by VCs, which in the view of the British Business Bank (Roper and Owen, 2024) have developed to enable VC (including Corporate VC) to get earlier access to high potential scalable venture propositions. This responds to the trend for business angels to invest in larger networks and follow-on invest at later stages, thus restricting the pipeline of high-quality ventures for seed VC. Our study revealed a range of types of venture studios operating across the early-stage finance escalator, including private seed VC, Corporate VC, as well as public launchpads, such as the Connected Places Catapult, Scottish Enterprise, Imperial College's SynbiCITE (engineering biology) and IUK's new regional launchpad programme. A common approach of these studios is to bring together networks of academic, industry and financiers to assist entrepreneurs to solve real world problems and build innovative business solution concepts and suitably skilled management teams to attract early-stage, private investment. IUK has extended their launchpad programmes in 2024 to include nature positive ventures, focusing on agtech.

3. Increasing activity of venture banking

High street banks (e.g. Barclays and Santander) and specialist impact venture banks (e.g. Triodos and Turquoise) are increasingly willing to invest in climate tech, particularly with the growing acceptance of carbon measurement (tCO2e/GHGe[15] and to some extent carbon credits). There has been slower uptake in nature-based solutions investment, although Barclays Eagle Labs is supporting the 2024 cohort for Carbon13 venture studio which will focus on agri-food solutions.

One Bank respondent commented; "*Banks are concerned with a combination of regulations, customers and reputational risk. They will react to trends from longer horizon investors such as institutional investors and will assess key higher risk sectors which will include oil and gas, infrastructure and agri-food*." UK High Street Banks like Barclays and Lloyds have considerable exposure to high proportions of farmers within their SME bank portfolios and are taking steps to engage with the greening of this sector. Banks are now amongst the most active financiers in engaging with government and private sector environmental metric solutions, in the pursuit of SBTs (Table A2). They are recruiting in-house teams of ESG sustainability experts to guide their sectoral support programmes and bank policies. Banks are now at the forefront of formalisation practices and working closely with the TNFD and DEFRA to develop nature based SBTs to address their SME farming portfolios.

SBTs and the reduction of Information Asymmetries

All actors in the UK green entfin ecosystem are struggling to answer, as typified by one impact VC fund manager's comment "*What does a 10x nature positive market investment look like?*" Harrer and Owen (2022) argue that information asymmetries are the main barrier to green business investment and that these are particularly acute for earlier stage green innovation. Our findings support this and the TNFD (2021) and Central Bankers (NGFS, 2022) views that science-based

15 Tonnes of carbon dioxide equivalent greenhouse gas emissions

targets (SBTs) need to be established for nature to provide clearer understanding of the environmental baselines of business activities, which is heavily nuanced by industry sector activities.

Private and public investors have different institutional logics (Fisher et al., 2017), with private investors favouring commercial market profitability from pure financial returns, whilst public investors seek public good (such as improved environment, health, food and water systems, safety and security).

However, we find a merging of these logics as public actors seek financial returns for the Treasury, whilst increasingly green impact investors are seeking to make a substantial difference and embrace an environmental sustainability logic by raising the market's environmental performance baseline. As one green angel said, they "*now look for [green] game changers and want to invest in big impact companies that are closely aligned with my vision for disruptive change*." These early-stage green impact investors (public and private) still prioritise financial returns but also want to see demonstrable environmental improvement. The question is then; how do they go about this? Investors recognise the danger of 'greenwashing' by investing in ventures that say they are green but do not improve on the environmental baseline of business performance. (As noted previously, in some cases there has been a rise in 'greenhushing' where 'being green' can bring with it reputational damage where sustainability claims (and progress) might be challenged).

Public and private investors interviewed (Appendix Table A2) agreed that low carbon measures for Climate Change impact, namely the reduction of greenhouse gas emissions and reduction in the use of carbon-based raw materials are well established - predominately measured as the tonnes of greenhouse gases saved (tCO2e). For many green investors (e.g. public and private VC and green angels), climate change is their fundamental goal, rather than nature-positive (arguably in part because of legislative drivers and comparative ease of measurement in more established carbon trading markets). However, they recognise the synergies between meeting net-zero and nature benefits (i.e. rewilding and regenerative farming activities) to achieve this and angel investors such as GAS have invested in ecological services (such as Nature Metrics and Bunloit).

Therefore, where nature-positive innovations can be measured in terms of net-zero lowering of carbon, they are more readily investible. However, this approach may not consider biodiversity impact (e.g. the negative impacts of introducing monoculture forestry, invasive species or positive impacts of attracting pollinators). In the absence of comprehensive SBT guidance for circular economy ventures (such as from TNFD or government-mandated standards), investors must navigate a fragmented landscape of multiple voluntary frameworks including ISO 59000 series standards, the Circular Transition Indicators, and various reporting mechanisms being integrated into European Sustainability Reporting Standards (where there is a European connection) and the International Sustainability Standards Board (ISSB). Many investors rely on proprietary measurements or third-party services (e.g. ESG consultants, supply-chain carbon trackers, Sustainalytics, GIIN/IRIS) to evaluate circular economy investments. In contrast, for biodiversity measurement in development projects, DEFRA's statutory biodiversity metric provides a standardised, mandatory framework for Biodiversity Net Gain.

The need to avoid carbon tunnel vision

There is a lack of understanding and consistency in the nature-positive measurements being adopted. This leads to the restriction of green impact investments and a focus on net-zero energy and material efficiencies and savings that serve both the financial and environmental public good logics. Whilst this can be more easily measured from an overriding financial return perspective, it does not necessarily support more rounded nature-positive solutions.

> "We need new solutions. If we want to see change, we therefore need to measure it, promote it and ultimately to invest in it – to encourage further innovation." - Series A VC.
>
> "Tech solutions offer low-cost and easy to operate dynamic measures." – Accelerator.
>
> "Examples of valuing nature are the clear value of kelp as a carbon sink … carbon sequestration value in carbon credit markets. However, large nature-based solutions often fail to provide impact evidence!" – Seed VC.

Environmental measurements are often blurred in relation to biodiversity, due to perceived lack of measures and baselines. Proxy indicators (such as DEFRA's statutory metric for BNG - DEFRA 2023a, b) and selective UN Sustainable Development Goals (SDGs) are used in conjunction with key performance indicators (KPIs) that appear to meet the needs of particular venture cases, but which have no wider benchmarking standing (e.g. Table A2) - as demonstrated in the use of SDGs to devise case measures by VCs and GAS. There was surprisingly little mention of TNFD or nature-based measurement platforms by respondents, except by Venture Banks, who have key sector-based customers that are affected by environmental reporting regulations like farm, food and property development (e.g. with mention of farm-related metrics and BNG). Soil quality and land habitat metrics emerge as the main biodiversity proxy measures mentioned by banks and equity investors, notably for farming and development respectively.

Overall, we reveal a complex mix of protected proprietary scorecard tools which are not shared by VCs and angels and case by case tailored solutions. Where external third-party tools are used these are most likely carbon trackers, or public sector programmes adopting environmental impact assessment (EIA) and circular economy (CE) consultancy measures (Table A2). There is a need for broad national and internationally accepted environmental indicators and baselines (Harrer and Owen, 2022) through the adoption of SBTs to overcome information asymmetries and better value nature-related dependencies. This will be inherently material and sector based.

"Measurement is not one size fits all, it is material based and has to be tailored to different business models." - Seed VC.

SME Ecological Services are key, dynamic bottom-up actors

To address the question of how SME innovators can deliver the science-based evidence behind SBTs we draw on evidence from our interviews with 10 UK SME ecological services innovators. They are using and developing leading-edge technological solutions to measuring the natural environment (e.g. habitat) and specific biodiversity of flora, fungi and fauna. This focuses on key sectors where regulations such as planning, pollution control and land restoration apply. Table 2 demonstrates their range of ecological service, indicating the current and future expectations of the demand for such services. Some, like the BNG and rail network consultants are already

offering environmental services, using third-party tech support, whilst others like Nature Metrics and PES are developing and piloting new technological measurement services. Some are in revenue through consultancy services whilst others are still at pilot pre revenue stages.

Company name (founded)	**Code**	**Employees**	**Location**	**Description**	**Funding**	**Stage**
Alo Mundus (2021)	E1	6	London	Urban tree planting /monitoring	Accel, 2x grants £50k, 350k	seed pilot, pre revenue (now in zombie status)
Chirrup (2022)	E2	4	South West	Acoustics bird song recording	£100k grant	seed pilot, early revenue
Baker Consultants (2009)	E3	17	Midlands	Acoustics inc. soil/worms	£250k grant/self-matched, need £500k VC	scale/seed VC
KymaRail (2017)	E4	1	South West	Rail /tech design consultants	Self-funded, needs grants/debt	seed revenue (now ceased trading)
EnrichGeo (2022)	*E11	9	Midlands	GIS/geospatial and farm market solutions	Angel and self-funded, seek £100k seed	Seed, pre revenue
Watr.Tech (2017)	*E5	12	East	Water tech measurement	£750k accel/angel seed	series A early revenue
BX.(Earth) Tech (2013)	*E7	2	South East	Farm consultants	Supply-chain financed, seeking angel/VC	Seed
PES Tech (2017)	*E8	9	East	Soil consultants	Accel, grant, angel, VC, 2x seed rounds £2m+	scale/ early revenue
Wildwood (2008)	E6	13	South West	Planning consultants BNG B Corp	Self-financed	Established/ revenue
Nature Metrics (2013)	*E9	150+	East	eDNA water and soil	Grant, angel, VC foundation, of £25m+	Scaleup/ revenue

Table 2 | Ecological Service Case studies (interviewed 2020-23; * 2+ interviews). Note: Green=Accelerator; Yellow=grant, Orange=business angel; Blue=VC

The financing of these companies, particularly the R&D innovators, sheds light on the problems of SME innovators in overcoming UK finance market barriers to deliver the required SBT solutions. Almost all (9/10) have required external finance, and where this involves extensive R&D and pilot work - particularly in developing hardware - the investment costs are considerable, amounting to several million pounds in the case of Nature Metrics and PES.

Notably, the UK finance escalator is accessed with heavy reliance on early-stage public grants (6/10) from IUK or via DEFRA's NEIRF programme as a proof of concept, early investment

readiness pre-seed or early seed stage platform for the venture. These grants can extend to larger scale public-private matched funding of up to £350k. There are also signs of emerging venture studio and accelerator launchpad pre-seed support (3/10) from private and university providers. As expected, from the more traditional finance escalator, business angel (4/10) and seed VC (3/10) are the main seed and series A sources, whilst equity crowdfunding (and other forms of crowdfunding which may not be suitable for long horizon R&D) is often not used. There is also the challenge that some public grant investment requires (sometimes unexpected) upfront funding of costs by SMEs until payments are made, which can impact on liquidity.

There is also evidence of international investment from accelerators and VCs, notably from the US. A trend here is that many ecological services are working with the agri-food sector where measurements of soil health and carbon content are particularly vital for consultant agronomists as advisory tools for farm practices. As the most advanced services like Nature Metrics progress to international market scale-up, they require larger multi-million funding, often from international investors and foundations to facilitate further innovation and international market access.

The failures of at least two (one ceased trading, one in 'zombie' inactive status) of the featured case studies during the past four years is testament to the difficulties to fund R&D and secure commercial markets for early stage cleantech nature positive SMEs. Many biodiversity ecological services have a lengthy and expensive R&D gestation time, leading to a long valley of death high-risk investment period. The valley of death period is extended where they require hardware development "…*which is expensive and often takes longer to refine and bring to market"* and where they struggle to find and demonstrate their market niche; "*We have many potential applications, including environment and health."*

There are also pitfalls for shorter horizon software developer AI companies, seeking to develop biodiversity measurement services. More established ecological services SME respondents noted "…*there are new big data companies coming into the market, but they are looking for ways to utilise AI tech without understanding the market*." For investors, consultancy companies that are not offering new R&D for their services and therefore lacking niche IP, this can be a deal breaker. As one VC investor stated, "*We have seen the first wave of ecological services and are looking for a distinctive second wave."*

Amongst the maturing first wave of SME innovation the leading technology is eDNA delivered by Nature Metrics. The company is global, but has struggled to penetrate farming markets, making greatest impact where developers and mining companies have been able to afford their cutting-edge services to assess; for example, windfarm planning application environmental impacts and the monitoring of land decontamination in mining areas.

"eDNA offers a wide range of water, soil and air biodiversity measurement which enables baseline and subsequent timeline checks for species richness [presence] and abundance… the science is advancing to enable greater understanding of ecosystem interactions and change over time… which are important in measuring the impacts of mitigation activities."

SME innovators are delivering the science and are often "*ahead of public policy*". Nature Metrics eDNA measurement of biodiversity species presence and abundance in land and water goes beyond the UK BNG land habitat quality measurement requested by the statutory BNG metric. As demonstrated by the Autumn 2023 delay to the roll out of BNG, these businesses suffer from lack of consistent regulatory support, meaning that there is no imperative for potential clients to adopt services (e.g. sustainable practices in the construction sector).

Furthermore, low-margin SME sectors like farming find the cost barrier associated with some eDNA technologies preclusive and may benefit from less expensive soil and water quality measurements, which may be less accurate or all-inclusive of biodiversity measurements, but may offer practical solutions. For example, PES Technology offers affordable (£3k) kit which uses inexpensive replaceable sensor slides that enable agronomist advisors to offer a broad set of real-time field soil quality data, whilst Watr.Tech provides a similarly affordable real time monitoring kit for water quality (but not specifically biological species measurement). Ultimately, eDNA offers the more expansive biodiversity measurement, but currently requires multiple detailed eDNA lab field sample tests at £200 per unit test (which do not offer real time assessment).

Intermediary services as conduits for success

Public and private market support services play a crucial role in developing the UK SME nature-positive early-stage investment market. We found, in line with Harrer and Owen's study of UK cleantech, that intermediary service providers are developing and delivering solutions (Harrer and Owen, 2022). In the private sector these have been led by ESG consultants from industry, finance and sustainability backgrounds who are mainly assisting banks, accountants and larger institutional investors. They also include financial data services (credit agencies and insurers) that are helping financiers to calculate the risk-reward for environmental investment and loans.

Private SME support agencies, often together with public finance, offer assistance for research commercialisation, networking development and investment readiness. They are also instrumental in developing climate hub (carbon trackers) and nature-based tools (geospatial calculators). From the public sector, this has involved national agencies (e.g. sector themed innovation Catapults), local authorities addressing place-based environmental solutions including through planning and pilot BNG programmes, and universities as spinout and SME innovation support providers. The embodiment of this approach is of mission-driven venture studios, which are key drivers of change within the green early-stage innovation market and are seeking to bring together business and societal problems, entrepreneurial innovation solutions and public and private financing.

Co-creation and collaboration for more effective ecological services

Co-production of ecological service development through collaborative SME innovation is often missing at national and international scales. Yet, our evidence demonstrates that ecological services are often co-dependent on working with other complementary services to provide the most effective measurement solutions.

EnrichGeo, a young venture established online during the COVID-19 pandemic, brings together the sectoral farming know-how of universities in Nigeria with IT technicians from India to deliver geospatial satellite and drone tech to guide farmers in their sustainable crop management. This service cannot operate without external soil sampling and water testing support services. It also forms part of a larger project to create an export market to the UK for environmentally friendly organic cash crops. This requires the establishment of an effective supply chain which meets with UK import standards for perishable food products.

Likewise, BX tech developed accreditation of the first carbon negative farm in the UK to demonstrate to the supermarket Tesco that an established fruit farm could operate in an

environmentally-positive way and deliver high quality premium organic products. "*This model effectively reversed the process of [the] supermarket as price-driver, since the farm could obtain supply chain investment and improved margins, if we could prove our practices*." This was achieved through rigorous monitoring of crop management and soil carbon measurement through third-party services.

Both examples from the low-margin farm sector demonstrate the need for co-created, combined complementary service delivery, which may be undertaken through international networks. Within the UK, there appears to be a need for networking of these emerging services. For instance, if eDNA for airborne species is under-development, supplementary techniques of acoustic and photographic evidence could be used - particularly where it detects the presence of apex and key species, such as birds of prey and bees that provide strong proxy indication for the presence of a wider area-based support pyramid of species.

The key emerging measures

The TNFD framework (September 2023) incorporates broader socio-environmental considerations including support for Indigenous Peoples and includes biodiversity metrics (which is operationalised in the more recent Nature Action Portal). However, biodiversity measurement remains challenging in practice, as the framework (Table 3) addresses nature loss through multiple interconnected drivers (climate change, pollution, land use change, resource exploitation, and invasive species). The TNFD's LEAP guidance provides a structured assessment process, but establishing robust, quantifiable causal links between specific mitigation practices and biodiversity outcomes remains an area requiring further development as organisations begin implementation. TNFD includes biodiversity metrics but acknowledges data challenges. The framework balances scientific rigour with practical implementation, Overall, whilst there are clear recommendations for biodiversity metrics (Table 3), these remain as 'placeholders' in the TNFD (2024)[16] recommendations for financial institutions, under for example the EU Sustainable Finance Disclosure Regulation (SFDR), because they remain difficult to collect and require specific sectoral material contextualisation.

Our findings suggest that new innovative SME ecological services like Nature Metrics' eDNA measurement are advancing beyond existing biodiversity assessment approaches. Whilst the UK DEFRA statutory biodiversity metric measures biodiversity through habitat-based proxies (habitat type, condition, connectivity – Defra 2023a, b), Nature Metrics' eDNA approach provides direct, place-based records of species presence and biodiversity in land and water over time (e.g., in mining area restoration). This supports all stages of the mitigation hierarchy through screening, baselining species groups/richness and community structure, time series monitoring, restoration monitoring, and measuring biodiversity net gain. Through time series place-based eDNA data capture and AI algorithms, they are establishing natural ecosystem connectivity data that complements habitat-based assessments. Of course, as a one ecological services interviewee stated: "*We cannot deliver a silver bullet for nature in the same way that carbon can be measured for climate change, but we can deliver silver bites.*"

16 https://tnfd.global/wp-content/uploads/2024/06/TNFD-Additional-guidance-for-financial-Institutions_v2.0.pdf?v=1728035523

Ecosystem Realm	Metrics	Data Key Sources	TNFD Core Metric	SME Service
Water/Freshwater				
Water flow	m3; people/business count	TNFD, UN SEEA, ICMA	Freshwater quantity	Water.Tech
Flood mitigation	flood frequency; people/buildings; land loss km2	GRI, ICMA, UN SEEA, TNFD	Ecosystem services provision	Water.Tech
Purification	pollutants removed; km2 area habitat covered	UN SEEA, Capital Coalitions, TNFD	Freshwater quality (N, P loads)	Water.Tech
Water supply/quality	m3, water return quality	UN SEEA, TNFD, GRI 303	Water consumption, discharge	Water.Tech
Marine/Coastal				
Coastal protection	km2 covered; buildings at risk	Maes, UN SEEA, TNFD	Sensitive location identification	-
Soil erosion	Land Domain ecosystem retained pollution removed	UN SEEA, TNFD, EFRAG	Pressures on land/sea	EnrichGeo
Soil quality	biodiversity metrics	UN SEEA, TNFD, SBTN	Land degradation	Wildwood
Pollination	km2 covered	TNFD, GBF Target 10	Ecosystem services	EnrichGeo
Land/Terrestrial				
Cropping, grazing, wood	biomass, provisioning	UN SEEA, Maes, TNFD	Land use and land-use change	Wildwood
Animal/plant	biomass	UN SEEA, TNFD, GBF	Threatened species	-
Climate services				
Regulators	Climate Domain tCO2e reduction; tCO2e absorption	UN SEEA, ICMA, TNFD, SBTN	GHG emissions (Scope 1,2,3)	Alo Mundus
Weather hazards	people/buildings affected pollutant absorbed	UN SEEA, TNFD, IPBES	Sensitive locations	EnrichGeo, Nature Metrics
Air filtration	pollutant absorbed	UN SEEA, TNFD	Pollution reduction	-
State of Nature				
Habitat	Ecosystem Domain Habitat type, quality, change km2	EFRAG, TNFD, GRI 101, IPBES	Extent of ecosystems	EnrichGeo, Wildwood
Composition	eDNA species abundance, variety, counts; key species change	EFRAG, TNFD, GBF, IUCN	Species populations, threatened species	NM, Chirrup, Baker Consultants, PES
Function	energy store of plants, types of plants (Native key species)	EFRAG, TNFD, SBTN	Ecosystem integrity	Wildwood
Population	Numbers and breeding habitat	RSPB, EFRAG, TNFD, GBF Target 4	Species extinction risk	Wildwood, Nature Metrics
Extinction risk	key species numbers and habitat change	EFRAG, TNFD, IUCN Red List	Red List Index	Nature Metrics

Table 3 | Emerging Science Based Target Measures for Biodiversity (adapted from TNFD, 2022)[17]

17 https://tnfd.global/tnfd-releases-second-beta-framework/

Through a combination of ecological services, more of the required measurements are being delivered. For example, in the case of agriculture a combination of satellite and aerial monitoring can check for ploughing, tilling and deforestation (i.e. EnrichGeo), whilst machinery emissions can be calculated alongside pesticide use, soil health (PES) and water quality (Watr.Tech) measurements. All these factors can be measured alongside eDNA soil and water biodiversity (Nature Metrics) and visual (Wildwood, ecologist boots on the ground) and acoustic evidence (Chirrup, Baker Consultants) through scientific tests that are becoming cost-effective.

Furthermore, biodiversity measurements can be repeated over time to measure the impacts of mitigation practices. This science-based certification of evidence will increasingly impact on finance markets, enabling more accurate quantification of biodiversity related risks and market opportunities including greater likelihood of demonstrating business model environmental value to investors/shareholders, insurers, customers (B2B and B2C) and regulators.

Conclusions and Recommendations

This study of the UK early-stage green innovation finance market sought how to measure and report green, nature positive, financial risk and mitigation impacts and deliver an effective SME green finance market? Here, we summarise our key findings and make recommendations for policy and practice.

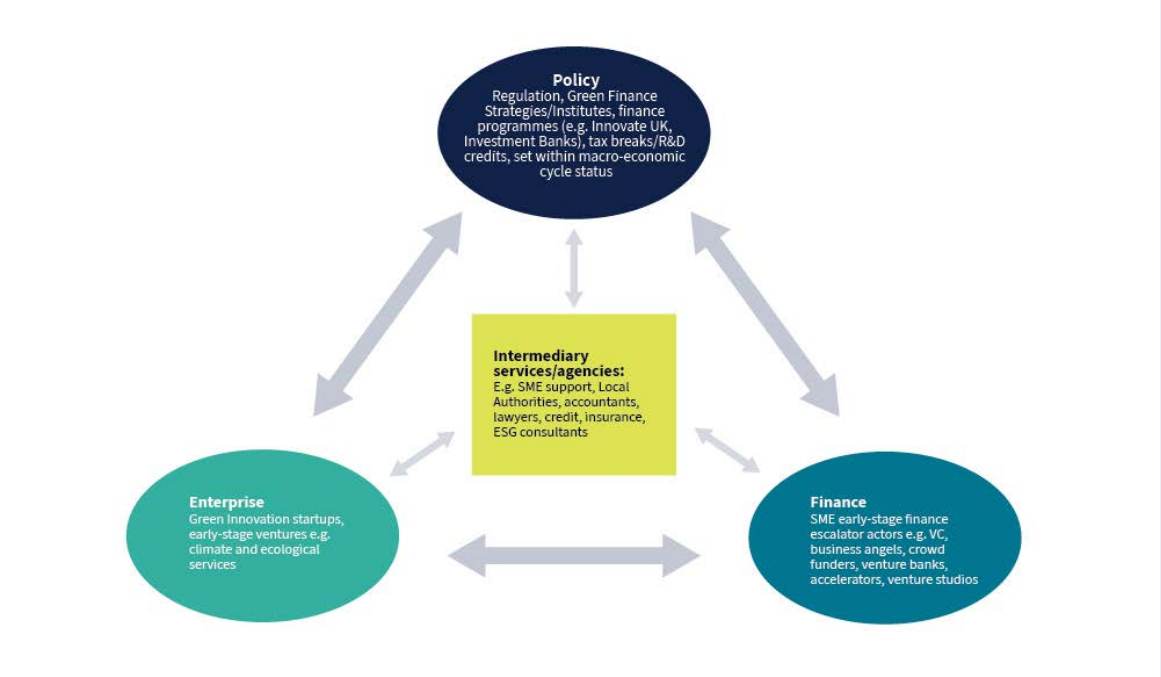

Figure 6 | Drivers and linkages in the UK early-stage green innovation ecosystem (see also Mukherjee et al., 2024)

How to measure and report green nature positive financial risk and mitigation impacts?

Drawing on a broad evidence base of 88 interviews of stakeholders from the UK early-stage green innovation entfin ecosystem, including businesses, public and private investors, support agencies and policymakers, we reveal a complex, often disjointed, ecosystem network (Figure 6). Here, the drivers of change relate primarily to the tensions between government policy and regulations, the goals of the private finance markets and the financing need of green innovators. Intermediary services that bring together public and private financing are vital to meeting the financing challenge and help to deliver the frameworks and metrics to assist early-stage finance markets (*Figure 5*). Our key findings and recommendations follow:

Environmental nature-positive measuring and reporting

1: Environmental reporting regulations are the most important driver on UK finance markets, but they do not directly impact on the early-stage green innovation finance market

Our longitudinal evidence (2022-2025) demonstrates the top-down cascading influence of environmental reporting. This has initially impacted on the large institutional investors and banks that have mandatory reporting requirements. However, earlier stage investors are only influenced by public policy where they are subject to larger investor scrutiny, such as LP investors in VC, or public co-financing requirements. There is no consistent approach by the public sector, apart from for specific targeted funds (e.g. Clean Growth Fund, Low Carbon Innovation Fund) to require environmental impact reporting.

Recommendation: All public funding (including early-stage innovation) should have a mandatory low-carbon impact reporting requirement and work towards establishing a nature-positive reporting framework. This will help with improving the alignment of the UK emerging green finance escalator, ensuring that early-stage green innovators are prepared to meet the reporting demands of later stage investors.

2: Science-Based Targets (SBTs) are required for nature positive reporting to operate effectively within the finance market

There is consensus that climate change carbon reporting is understood by the finance markets – although the proliferation of carbon tracker tools needs to be streamlined to an accepted full three-Scope approach. However, the lack of SBTs for biodiversity, which is considered complex and difficult to understand for investors urgently needs to be addressed. A worrying unintended consequence of the success of carbon measurement is that early-stage impact investors are drawn to this when evaluating nature positive venture propositions, which means that nature positive ventures which improve for example pollination, may be overlooked.

The Science-Based Target Network's 2023 release of initial nature targets addresses key drivers of biodiversity loss through freshwater and land metrics, yet comprehensive biodiversity state-based targets remain in development, reinforcing the need for accessible measurement technologies that support SME inclusion whilst frameworks continue to evolve.

Recommendation: Focus public research funds into supporting nature-positive measurement solutions such as eDNA, satellite, visual, audio and sensor measurement which can offer biodiversity or suitable land and water quality proxy measurements. For instance: (1) making these innovations affordable and accessible for SME adoption; (2) supporting collaborative measurement approaches that distribute costs across multiple smaller businesses; and (3) providing capacity-building alongside technology access. This includes supporting communities and other stakeholders to deliver this work at scale through integrated approaches and governance (i.e. citizen science). However, this must not exacerbate the existing plethora of metrics and an urgent convergence of frameworks and their interoperability is required, especially where this supports the inclusion of SMEs in their reporting.

3: Innovation in nature-tech is ahead of policy, but it requires stable policy and regulation to assist market adoption with natural biodiversity ecosystem-related impact measures. Biodiversity Net Gain (BNG) provides an initial formal approach to create a market mechanism through nature-positive reporting (through its operation in the planning system), but it is only a proxy habitat measure for biodiversity (i.e. rather than delivering species performance measures). It is vital that nature-tech offers practical and accessible measures for SMEs.

Case studies, such as Nature Metrics demonstrate that new tech that adopts eDNA and AI algorithms can generate biodiversity baseline data and effectively map dynamic changes and the impacts of mitigation practices over time. This is precisely what SBTs require, but it will not be delivered if there are market uncertainties about the longevity of regulations and the costs of adoption.

Recommendation: Beyond the planning system, subsidise pilot measurement studies in different industry sectors, such as farming where there is often not the profit margin to pay (costly) experimental services. Regulations should be regularly updated in this rapidly progressing tech-driven market, based on sufficient pilot evidence – suggesting a need for more reflexive approaches to regulation and policy-making, especially in planning systems.[18] Natural (and related social) ecosystem impacts should also be considered at scale.

How to deliver an effective green nature positive SME innovation finance market?

4: The evolving UK green innovation finance escalator is complex, often fragmented and siloed

There are dynamic, exciting developments in the UK's early-stage green impact investing markets. At the foot of the finance escalator, these include private and public launchpad and venture builder studios designed to develop the venture teams and develop research ideas into commercial real-world innovative solutions. The introduction of matched public grant and early equity funding demonstrates the benefits of obtaining technical (grant peer review) and commercial (investor backing) earlier in the venture start-up stage. Whilst this grasps the importance of networking the entfin ecosystem to create investible venture propositions, there is often lack connectivity to later stage financiers and to the pivoting requirements of the ventures. Our ecological services case studies exhibited early grant and equity funded ventures, which

18 https://hive.greenfinanceinstitute.com/gfihive/neirf/

struggled to find a market and would benefit from a more open and collaborative research approach which brings together complementary services to provide nature positive measurement solutions.

Recommendation: Extend venture builder support to include a more holistic approach to venture development, which can involve open research collaboration and the ability to (i) match research to industry innovation requirements and (ii) new venture services together through the stages of their development.

5: The linkages between the different stages of the public green finance escalator remain complex and disconnected

Our research supports the recommendations of the Willow Review (2025) to the UK government for a simplified, integrated green oriented finance escalator connecting government, financial services and SMEs. We demonstrate that green innovations are long-term investment propositions, which typically take many years to commercialise and require many funding rounds of different types of finance as they progress through the stages of the finance escalator. Early-stage green innovators are heavily reliant on grants and equity but often experience delays in follow-on funding and limited drip-feed funding rounds which hold back their development. Successive evidence from the British Business Bank small business equity tracker studies (2021-2023) demonstrates that whilst the early-stage equity markets have been well-served, successive rounds of finance through to scale-up exhibit under-funding, particularly for patient capital deeptech and hardware, such as cleantech.

Recommendation: As per the Willow Review recommendations, develop a transparent holistic SME green innovation finance roadmap which strategically brings together the appropriate government funding agencies to ensure that high priority cleantech (which address national Net Zero and 30 by 30 biodiversity targets) are supported with appropriate public funding. Consider prioritising the most promising cleantech for large-scale state support, as in the case of France's *'Tech Green20' programme*. This can leverage start-up innovation into the coordinated, mission-led approach to supporting SMEs and Voluntary, Community and Social Enterprises (VCSEs) into green innovation procurement opportunities through the emerging new procurement regime under the 2023 Procurement Act.

6: Early-stage private environmental impact investment by business angels and seed VCs are currently primarily motivated by the personal choice of individual investors and fund managers

Smaller-scale early-stage green impact investors are primarily driven by personal choice to invest in climate and nature, which they typically state must offer a competitive market rate of financial return. The increase in recent years in angel and seed VC impact investors has therefore been driven as much by climate aspirations (and to a much lesser extent biodiversity) as expectations of returns. The indications are that the current UK economic downturn which has seen a slow-down in early-stage equity investment (BBB Small Business Equity Tracker, 2023) could also curtail green investment. Notably, this is likely to impact most on longer horizon patient capital investment (as it did during the 2008 global financial crisis).

Recommendation: Enhance government support for early-stage green investment through an expanded direct stimulus via the Enterprise Investment Scheme (EIS). This enhanced scheme

should not only support green innovation but also provide longer investment horizons with improved tax relief terms for investments held for at least five years (rather than the current three years), particularly where they demonstrate added environmental and social benefits.[19]

7: Intermediary services provide important frameworks for measuring environmental impact and conduits for bringing together public and private finance to green nature positive early-stage innovators

Our research highlights the pivotal role of intermediary services such as ESG consultants, brokers and support agencies that can bring together public and private funding provision for early-stage green ventures. This has been highlighted in the role of public funded launchpads delivered by catapults, local authorities, universities and subsidised private consultancies and in the evolving post- global financial crisis role of SME finance brokers. Given the fragmented and often localised finance markets that exist in the UK - and notably in England under the Shared Prosperity Fund - there is a need to ensure local authorities have the funds to support local SME green innovation.

Recommendation: Provide targeted national green funding streams to local authorities (e.g. through the (now reduced) Shared Prosperity Fund and place-based initiatives) that enable them to establish green innovation support hubs. This could be complemented by guidance to manage localised nature-based schemes that support nature-positive business support schemes and public green infrastructure projects, especially in the context of potential innovation that can be supported under a move to widen devolution. This should involve SMEs (especially early-stage innovators) and community-based nature-positive innovators as co-designers in such schemes to leverage and extend nature markets beyond statutory markets, such as BNG.

19 It is noted that the UK Autumn Budget, 2005, provided a welcome rise in EIS investment thresholds, but failed to offer specific green or long horizon investment incentives.

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Appendix 1 - Detailed Methodology

A qualitative evidence-based approach was adopted (Cresswell, 2003). This was informed by our review of the SME entfin literature and limited UK secondary data (e.g. LSBS waves, 2017-2022; Gottschalk and Owen, 2023). We undertook qualitative semi-structured interviews (Creswell, 2003; Yin, 2009). This triangulated a broad base of evidence from across the entfin early-stage innovation finance ecosystem, as per Harrer and Owen's (2022) triple nexus of green financing to include (i) green innovation entrepreneurs, (ii) public and private financiers and (iii) related intermediary support infrastructure services.

Key Informant	No.	Organisations Represented
Supply Finance	**N=43**	**Investors**
Venture studios/incubators	7	Bloom, Carbon13, CPC, SynbiCITE, SETSquared, ElevatorUK, Zinc
Accelerators	3	Accelar, Bethnal Green Ventures, Sustainable Ventures
Business Angels	7	GAS x4, Minerva, Seedtribe/FiveThirteen, Cambridge Angels
Seed/VC	10	TfT, Regenerate, EFT, OnePlanet (UKI2S), Octopus, FuturePlanet, Ascension, ET Capital, SyndicateRoom, Farmhand Ventures
Green Banks	3	Turquoise, Triodos, Oxbury
Banks	6	NatWest, Barclays, Lloyds, HSBC, Santander, ING
Public funds	7	CGF, LCIF, Welsh Angel Fund, WDB Tech Fund, BNIF, NEIRF, IUK Launchpads
Intermediaries	**N=35**	**Market supporters and larger business supply linkages**
Trade Associations	6	UKBAA, WLB, WLCC, BIFA, FSB, BVCA
Accountants	6	KPMG x4, SME accountants x2
Consultants	6	6x ESG consultants, BWB
Enterprise Agencies	1	Oxford Innovation (multiple locations)
Public agencies	9	BBB, WDB, Scottish Enterprise, DEFRA, IUK, DBT, LAsx3
Large Businesses	7	National Trust, Worcester Bosch, Liberty, KPM, Heathrow, Network Rail, CEVA
Venture Demand	**N=10**	**Ecological service innovation**
Ventures	10	UK-based private independent SME innovators, supplying guidance/measurement/monitoring tech services e.g. for BNG or ELMS

Table 4 A1 | Financiers, Ventures and Support Organisations interviewed (N=88, 2022-24)

Note: VC=Venture Capitalist; CPC=Connected Places Catapult; GAS=Green Angel Syndicate; TfT=The First Thirty; CGF=Clean Growth Fund; LCIF=Low Carbon Innovation Fund; WDB=Welsh Development Bank; BNIF=Big Nature Investment Fund; NEIRF=Natural Environment Investment Readiness Fund; IUK=Innovate UK; UKBAA=UK Business Angel Association; BVCA=British Venture Capital Association; WLB=West London Business; WLC=West London Chamber of Commerce; BIFA=British International Freight Association; FSB Federation of Small Business; BBB=British Business Bank; ESG=Environment Social and Governance; BWB=Bankers without Boundaries; LA=Local Authority; BNG=Biodiversity Net Gain; ELM= Environmental Land Management Scheme; KPM Marine.

Interview structure and format

This report focuses on the SME early-stage green innovation finance available in the newly emerging UK green finance escalator and specifically address our research question of how to measure and report green financial risk and mitigation impacts? Our aim was to understand how green impact financiers screen and monitor their portfolios to select and ensure that they are making a net positive environmental contribution.

Table A1 documents the key informant financier and organisation completed interview list, which was purposively generated to offer a broad representation of the UK's emerging early-stage public and private green innovation financiers and the support agencies and consultants (e.g. ESG consultants) that guide their approaches. Additionally, we interviewed early-stage entrepreneurial ventures focusing on delivering ecosystem service measurement, since these were in many cases having to demonstrate their environmental impact value to potential investors, as well as offering the future solutions for financial market environmental risk assessment. Our belief was that this focus would offer a vital early assessment of the emerging science-based targets (SBTs) which these innovators can provide measurements for.

Interviews were mainly undertaken online, typically lasting one hour and involved ongoing feedback and internet cross-referencing to corroborate evidence. The interviews explored through open questions (Kintzer, 1977): the profile of actor and their organisation; understanding of green investment markets (focusing on the UK); actions taken to overcome information asymmetries, relating to developing environmental impact assessments and screening and monitoring investments and lending portfolios; learning interactions between actors across domains to understand what works; the role of intermediary support actors; the role of public policy regulations and financial support; proposals for improving the operation of the SME green finance market in the UK. Many participants were interviewed at least twice, providing longitudinal insights into the developmental processes taking place (Owen et al., 2019).

Analytical technique

Qualitatively interviews were recorded where possible, alongside contemporaneous interview notes. The interview scripts were then sense checked for accuracy and meaning with the interviewees and triangulated with other evidence from the interviewee's website, Linked-In profile and other reliable internet sources and publications (e.g. white papers, blog reports). Qualitative data was then systematically analysed in word and excel by at least two researchers to avoid individual interpretive bias. Following Gioia et al (2020) a systematic abductive approach involving a structure borne out of the entfin ecosystem literature established an initial framework for the interviewee types and thematic questions. The subsequent data collection was then inductively coded into key emerging themes – determined by repetition and strength of interviewee conviction and triangulation data. Emerging themes, relating to the dynamic factors affecting the market and approaches to impact investment assessment were coded and form the structural basis for the findings (Harrer and Owen, 2022).

Appendix 2 - UK Green Finance Escalator

Measures/Approaches (n=31)	Influences/Third Party Tools (n=)
Series A: Public and Private VCs (n=2)	
Public (1): tGHGe reduction over time, EIA and CE - holistic d/d and monitoring *Private (1):* UN SDGs, case KPIs (e.g., energy/water/material savings), proprietary impact scorecard	NZ aims (sector/tech focus) Govt: DESNZ, EEF ESGs/SDGs *TPTs*: EIA/CE (1)
Seed VCs: Public and Private (n=10)	
Public (2): tCO2 reduction, EDI, in-house 'Carbonlytics' calculator = annual savings over industry average, DEFRA/ecosystem measurement *Private (8)*: ESG '5 principles'/'DNH', SDGs, EDI, tech for good/screening, PPP, soil, carbon tracking, in-house proprietary 'value gap' scorecard	Mixed NZ/NP (sector/tech focus) DEFRA, ERDF, BBB, EU Article 9, S/EIS, Finance Earth, Universities Peer US and EU VCs, LP Investors. Individual GPs, C13 *TPTs*: DEFRA 4.1, Carbon track (3)
Seed Business Angels (n=7)	
SDGs, *tCO2e reduction*, carbon tracking, carbon credit codes (peat, wood), soil, Just Transition, KPIs in-house case by case assessment	Mainly NZ (sector/tech focus) S/EIS, FCA, BBB, Investor networks *TPTs*: Carbon trackers (2)
Pre-Seed Accelerators/studios (n=6)	
tGHGe reduction, soil quality, carbon tracking, EDI, critical minerals reduction, Levelling-up/JT	Mission- led (specific cohorts) IUK, DESNZ, Universities, Climate Hubs, Investor networks, VCs, Banks, international accelerators *TPTs*: Carbon trackers (2)
Venture Banks (pre seed to Series A) **(n=5)**	
NZ scoping, *tCO2e* reduction, carbon tracking, UNEP 5 drivers of nature loss/DNH, DEFRA metric/BNG, ESGs, SDGs clean energy, agritech, pollution reduction, Soil Association Exchange farm metrics, soil and organic measures, PPP, JT	Mainly NZ (strong agri/sector focus) DEFRA, IUK, EU SFDR, TNFD, UNEP, Sustainalytics, Deloittes, Nature Metrics, Finance Earth *TPTs*: Carbon trackers, DEFRA, Farm metrics (4)

Table 5 A2 | UK Green Finance Escalator Early-stage Funders, Green Measures, Influences.

Note: tCO2e= tonnes of Carbon Dioxide equivalent measure; tGHGe= tonnes of Greenhouse Gases equivalent measure; EIA=Environmental Impact Assessment; CE=Circular Economy; SDG=Sustainable Development Goal; ESG=Environment, Sustainability and Governance; JT=Just Transition; DNH=Do No Harm; EDI=Equality, Diversity and Inclusion; Levelling-up=regional policy; KPIs= Key Performance Indicators; PPP=People, Planet, Places measures; NZ=Net Zero; NP=Nature positive; DESNZ=Department for Energy Security and Net Zero; DEFRA=Department for Environment, Food and Rural Affairs; ERDF=European Regional Development Fund; BBB=British Business Bank; IUK=Innovate UK; VC=Venture Capitalist; LP=Limited Partner investor in a VC fund; GP=General Partner, manager of VC fund; S/EIS=Seed/enterprise investment tax break; EU=European Union; FCA=Financial Conduct Authority; SFDR=European Sustainable Finance Directive; UNEP=United Nations Environment Programme.

Appendix 3 - DPSIR SME Green Innovation Guidance (source University of Reading)

The metrics outlined are not set in stone and can be adjusted, reduced or replaced. The idea is to give options which may be practical for SMEs. They are designed to be international and focus on measurable aspects of biodiversity rather and are colour coded:

Easy to assess basic measures	Requires more detailed supply chain maps or some investment	Requires detailed information or time-consuming data gathering	Aspirational and technical metrics

The idea is that the orange boxes should be easy for all businesses to do with the aim of gradually expanding to the harder ones (or aspiring to do so). A challenge within the literature is that it does not have a clear graduation of effort and this is a light and very early attempt to address this. Unless otherwise noted, these are assumed to be data that the company would have access to or could eventually gain access to through its supply chains/knowing its operational routes.

Biotechnology/Manufacturing Innovation Sector

Biotechnology is included as a sector principally for its role in monitoring biodiversity status. However, like all manufacturing, it draws heavily upon materials and resources which risks creating a situation where a company causes a lot of damage to make monitoring technology. Hence, this is assembled as a manufacturing focused set of metrics, focusing on minerals (mining) and biological resources (primarily forestry).

Land use	Pollution	Status	Responses
Volume of non-renewable resources used per product	Proportion of materials from non-renewable resources	Soil organic matter	Proportion of source materials that can be completely traced
Total area of resources extracted from mining and forestry (inc. packaging)	Proportion of soils in the area surrounding material extraction that are contaminated with heavy metals[20]	Diversity of species in freshwater (eDNA) in and around resource extraction sites	Proportion of product made from recycled materials
Proportion of resource extraction within 1, 5 or 10km of protected areas	Proportion of biological materials from intensive forestry or cultivation[21]	Common bird abundance in and around source material sites	Proportion of forestry under certified sustainable management

20 There are a number of companies offering (example) soil contamination test kits
21 This can include industrial crops such as borage and linseed. Intensive means tree monocultures that are not subject to sustainable forestry practices and crops produced with both synthetic pesticides and synthetic fertilizers

Average forest degradation in terms of % canopy cover losses[22]	Water footprint (particularly grey water) of product	Butterfly abundance around source material sites	Proportion of biological resources subject to sustainable and low input management
Proportion of biological resources from natural habitat (not plantations)	Total chemical contaminants in plants around mining/forestry	Abundance of rare or threatened species in and around resource sites	Proportion of mining land subject to regeneration strategies

Notes: For pharmaceutical companies and companies that rely heavily on timber or other forest products, the genetic diversity of cultivated and wild plants in their area of interest may be a more important metric. This genetic mapping is offered by several companies (e.g. Forest Research)

Selection of 'Status' metrics

The biggest challenge is that what species are most affected will vary a lot based on when and where activities occur. A chocolatier who buys cocoa from Cote d'Ivore and milk from the UK will have two very different sets of impacts. As such, our review mostly focused on habitat diversity freshwater species diversity, Plants, Birds and Butterflies. These are all widely used as indicators of broader ecosystem health.

General metrics and measures

Any company can theoretically use one of two tools to get a rough overview of their activities. The Biodiversity Intactness Index from the Natural History Museum, estimates the proportion of biodiversity that has been lost in a country over time and how this is likely to change. This only requires a company to know where its products are from and can be used to determine if it is sourcing from highly degraded countries. It is free to use.

The Cambridge Institute for Sustainable Leadership's Biodiversity Impact Metric is more detailed in that it takes the area of each land use and then compares this to the biodiversity change per unit area of swapping from natural habitat to that land use and multiplies this further by the uniqueness of the biodiversity in those areas. It is available for a fee.

The challenge with both of these is that they are things that a company cannot do anything about and cannot measure how their efforts have affected change. They can still provide a useful guideline on where to look into engagement on the ground or swap away from certain countries.

Finally, companies should try and keep tabs on the abundance of invasive species on their land. This will vary a lot between places but the UK lists (plants and animals) are hosted online.

Habitat Diversity

Habitat diversity inherently supports species diversity and is much easier to measure than the state of individual habitats, especially outside of the UK where detailed mapping data is scarce. This can be done very simply in a few ways:

22 This can be estimated using Global Forest Watch's mapping tools which allow users to draw polygons and generate reports from a range of metrics

1. Take a rasterised map (one that has been converted into a series of square pixels, usually at 100m^2 or smaller) of a 1-10km area around your material area (depending on how precisely you know where your fields are) and then, using freely available software like QGIS, simply estimate the percentage of the landscape that is non agriculture or urban area. Input map data can come from e.g. Global Habitat Type map or Copernicus
2. If the country is in the EU, you can use the more detailed CORINE land cover map that has more detailed habitat types and although ground truthing is always preferable. This can be broad if the exact location of field is not known. From this you can calculate a simple Shannon diversity index of the landscape.
3. In the UK, even more detailed maps are available through UKCEH that go down to 10m^2 and have a lot of extra details like crop types and smaller habitat features that can give a more accurate picture of the landscape.

Important: For UK case studies, Natural England's Biodiversity Metric can be used to capture habitat quality as well as extent. There is also a separate small sites metric for offices and other smaller infrastructure.

Main species

For all species, the number of samples would vary depending on the context of the survey, but for simplicity's sake, we assume these would be sampled every year.

Soil: Soil is key to ecosystem functioning and many activities can pollute soil killing the sensitive microorganisms within the community. Measuring these various microorganisms and the larger species that represent the higher part of soil functioning (e.g. earthworms and collembola) can be time consuming to do manually and requires very specialist training. eDNA offers a simpler solution to this (e.g. Nature Metrics) but ultimately the end result may not very useful as diversity can vary tremendously from point to point and may take decades for changes in populations of particular taxa to manifest. Hence, we recommend using soil organic matter as a simple proxy, as it is often used in ecological research.

Diversity of Species in Freshwater (eDNA): Freshwater quality as defined by the water framework directive is measured through a collection of different taxa, including insects, algae, zooplankton and fish, all of which are sensitive to different pressures. eDNA is a useful way to measure all of this at once, giving an overall picture of species diversity. Unlike soils, freshwater biodiversity can change in measurable ways fairly quickly with eDNA, hence I am proposing it's use here and not elsewhere. I am not an expert in freshwater biodiversity and can't say if this is a better indicator than field sampling, but it's certainly easier. Some details are outline in NatureMetrics White Paper.

Plants (Flowering plants, shrubs and trees): often this requires a specialist botanist to identify individual grasses and non-flowering plants but flowering plants are much easier to identify to a species or functional group level (see the National Plant Monitoring Scheme for a UK species list). The standard method is simple quadrat sampling but there are few user-friendly versions of this – the best being the one listed by the US Government's Sustainable Intensification Toolkit.

Birds: Birds are very well studied, and their monitoring is extremely widespread, with dozens of specialist organisations in the UK alone. They are excellent indicators of overall ecosystem health in both farmed land, wetlands and marine systems. Abundance is a key measure as this is fairly

straightforward to estimate following the Breeding Bird Survey methods. This involves taking some 1km squares of land and then recording birds observed to be nesting and those in flight only at different distances along a straight line. Over time, this can give an idea of the number of birds nesting in that area.

Bioacoustic monitoring is also of growing popularity within the research community and can deliver good results but there is not a widespread scheme yet and will require the development of wider reference libraries and needs some further refinement. Jackel et al (2021) review this.

Butterflies: Butterflies are a more sensitive indicator of overall ecosystem health but are also quite a well-known and easy to work with taxa. Estimating their abundance reliably is quite hard but the eBMS 15 min counts method (essentially staring at a patch of flowers in or around land that is being used, for 15mins in good conditions and recording the number of butterflies), which also aligns with the eBMS App, will give a simple count at least and, in some countries, diversity can also be estimated.

Other species groups

Moths: Moths are another excellent indicator of overall ecosystem health with well-established sampling methods, but they are a more involved than the methods for monitoring butterflies. They are however quite sensitive to light pollution, so these are included them as an option for Transport/Infrastructure measures. An overview of methods for sampling moths using low cost methods is provided by Butterfly Conservation.

Bats: Bats are similar to birds as good indicators of overall ecosystem health, however they are a lot harder to monitor without proper equipment and training. These are included them as a possible metric in the Transport and Infrastructure sector and they are becoming easier to monitor thanks to advances in bioacoustics, which are already used in the UK, but may still require specialist involvement.

Bees: Bees can be good metrics of wider biodiversity but are probably less suitable than butterflies as they include many social species where abundance does not necessarily indicate healthy wild populations (e.g. managed honeybee colonies can contain thousands of individuals) and many species are small, hard to spot or impossible to identify with the naked eye. As a broad group, bees can be monitored using the same methods proposed for butterflies (guidance from UK PoMS, which also has an app), but only 10mins is recommended here. They may be suitable for agrifood or fashion businesses who have a high dependence upon pollination.

Mammals: Mammals are a very popular metric of wider biodiversity in ecological research but they need to be monitored in a variety of ways, typically based around ungulates, carnivores, rodents (and other small mammals) and freshwater mammals. They also have less support and presence among the monitoring community than birds.

Rare and threatened species: These are very important to monitor where possible but can vary greatly. In many cases these will be mammals or birds as rare insect populations are almost always hard to reliably measure. For mammals, a range of tools such as eDNA of soil or more straightforward genetic analysis of faeces (e.g. Forest Research) or camera traps (overview from the Wildlife Trusts) could be used to identify the presence of these species without direct observation. Birds can also be identified from their song and increasingly bioacoustics tools can be viable for this. However, the exact protocol will depend on the species and region.

A best first step is to identify what rare and threatened species are most likely to be in the area and how they are likely to be affected. The simplest way of doing the former is to consult an IUCN database using tools such as IBAT.

Appendix 4 - Acronyms and Abbreviations

- **AI** – Artificial Intelligence
- **BBB** – British Business Bank
- **BEIS** – Department for Business, Energy and Industrial Strategy
- **BNG** – Biodiversity Net Gain
- **BVCA** – British Venture Capital Association
- **CE** – Circular Economy
- **COP** – Conference of the Parties
- **COP15** – 15th Conference of the Parties to the UN Convention on Biological Diversity
- **COP16** – 16th Conference of the Parties to the UN Convention on Biological Diversity
- **COP26** – 26th UN Climate Change Conference (Glasgow, 2021)
- **CPC** – Connected Places Catapult
- **CSR** – Corporate Social Responsibility
- **DBT** – Department for Business and Trade
- **DCMS** – Department for Digital, Culture, Media and Sport
- **DEFRA** – Department for Environment, Food and Rural Affairs
- **DESNZ** – Department for Energy Security and Net Zero
- **DPSIR** – Drivers, Pressures, State, Impacts, Responses
- **eDNA** – Environmental DNA
- **EIA** – Environmental Impact Assessment
- **EIS** – Enterprise Investment Scheme
- **ELMS** – Environmental Land Management Scheme
- **ERC** – Enterprise Research Centre
- **ESG** – Environmental, Social and Governance
- **ETL** – Energy Technology List
- **EU** – European Union
- **F4B** – Finance for Biodiversity
- **FSB** – Federation of Small Business
- **GAS** – Green Angel Syndicate
- **GBF** – Global Biodiversity Framework (Kunming-Montreal)
- **GDP** – Gross Domestic Product
- **GHG** – Greenhouse Gas
- **GICS** – Global Industry Classification Standard
- **GIS** – Geographic Information System
- **GP** – General Partner (manager of VC fund)
- **GRI** – Global Reporting Initiative
- **HICL** – High Impact Commodity List (SBTN)
- **ICMA** – International Capital Market Association
- **IDBD** – International Day for Biological Diversity (UN)
- **IFB** – Integrating Finance and Biodiversity (programme)
- **IoT** – Internet of Things
- **IPO** – Initial Public Offering
- **IUK** – Innovate UK
- **KIC** – Knowledge Intensive Community
- **KPI** – Key Performance Indicator
- **LA** – Local Authority
- **LEAP** – Locate, Evaluate, Assess, Prepare (TNFD approach)

- **LEP** – Local Enterprise Partnership
- **LP** – Limited Partner (investor in a VC fund)
- **LSBS** – Longitudinal Small Business Survey
- **MDX** – Middlesex University
- **NERC** – Natural Environment Research Council
- **NEIRF** – Natural Environment Investment Readiness Fund
- **NGFS** – Network for Greening the Financial System (Central Bankers)
- **NM** – Nature Metrics
- **NP** – Nature Positive
- **NZ** – Net Zero
- **ONS** – Office for National Statistics
- **PES** – Payment for Ecosystem Services / PES Technology (company name)
- **PIE** – Public Interest Entity
- **R&D** – Research and Development
- **SBT** – Science-Based Target
- **SBTI** – Science Based Targets initiative
- **SBTN** – Science Based Targets Network
- **SDG** – Sustainable Development Goal (UN)
- **SDS** – Sustainability Disclosure Standards
- **SEIS** – Seed Enterprise Investment Scheme
- **SME** – Small and Medium-sized Enterprise
- **SPF** – Shared Prosperity Fund
- **tCO2e** – Tonnes of Carbon Dioxide equivalent
- **tGHGe** – Tonnes of Greenhouse Gas equivalent
- **TCFD** – Task Force on Climate-related Financial Disclosures
- **TNFD** – Taskforce on Nature-related Financial Disclosures
- **UK** – United Kingdom
- **UKCEH** – UK Centre for Ecology & Hydrology
- **UKRI** – UK Research and Innovation
- **UN** – United Nations
- **UNEP** – United Nations Environment Programme
- **US** – United States
- **VC** – Venture Capital/Venture Capitalist
- **VCT** – Venture Capital Trust
- **VCSE** – Voluntary, Community and Social Enterprise
- **WDB** – Welsh Development Bank

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- **HSBC**
- **Turquoise**
- **Zinc**
- **ING**
- **Innovate UK (IUK)**
- **Lloyds**
- **NatWest**
- **Oxbury**
- **Santander**
- **Seedtribe/Five-Thirteen**
- **Triodos**