Biodiversity as a Social-Ecological Capability: Extending the Natural-Resource Based View in Renewable Energy Systems

Abstract

Biodiversity loss is an increasingly critical sustainability challenge, yet within the *Natural-Resource-Based View* (NRBV) it remains undertheorised and is often treated as a generic environmental factor rather than a structuring social-ecological mechanism. This study reconceptualises biodiversity as shaping how environmental capabilities emerge and create strategic value. Drawing on an inductive qualitative approach supported by Fuzzy Cognitive Mapping, we investigate the solar farm sector in England – an ecologically embedded sectors characterised by mandatory Biodiversity Net Gain (BNG) requirements, complex land-use negotiation and multi-actor habitat management. Our analysis identifies three interconnected orientations – instrumental, integrative, and ecosystem-based – that capture distinct logics through which firms interpret biodiversity, mobilise resources and govern biodiversity-related capabilities. The study extends the NRBV by specifying how environmental capabilities evolve in biodiversity-dependent infrastructures and by broadening its boundary conditions. It offers a more ecologically grounded foundation for strategy and supports nature positive business models.

Keywords: strategy; resilience; sustainability; ecosystem; competitive advantage; natural-resource-based view (NRBV)

1. INTRODUCTION

Biodiversity[1] plays a foundational role in maintaining the natural processes essential for climate regulation, food security, and economic stability (Hong et al., 2021; Porto et al., 2020; Taskforce on Nature-related Financial Disclosures, 2023) and human wellbeing (Cardinale et al., 2012; Fisher et al., 2023). However, biodiversity is declining rapidly across much of the globe due to anthropogenic pressures (Brondízio, Díaz, & Settle, 2019; Díaz et al., 2019), causing damage of USD $4 trn to USD $20 trn per year (Giglio, Kuchler, Stroebel, & Zeng, 2023). According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2019), these losses are primarily driven by global economic systems that prioritise short-term growth over long-term ecological sustainability, resulting in intensified land-use changes, pollution, greater resource consumption and rising emissions (Otero et al., 2020; The Royal Society, 2020; Schaltegger, Gibassier, & Maas, 2023).

Businesses play a central role in shaping economic development and being major consumers of natural resources (White et al., 2023). However, biodiversity frequently remains a peripheral concern (Heras-Saizarbitoria, Boiral, & Díaz de Junguitu, 2020; Wagner, 2022), overshadowed by certain sustainability priorities that are perceived as more directly actionable or financially attractive (Panwar, Ober, & Pinkse, 2023). Milne and Gray (2013) argue that such peripheral treatment contributes to greater unsustainability, as it legitimises business–as–usual practices that fail to tackle the fundamental causes of biodiversity loss. Addressing this challenge requires systemic change (Damiens, Backstrom, & Gordon, 2021; Smith et al., 2021), including re-evaluating existing theories that underpin environmental dimensions of business practices.

In the field of strategic management, the Natural-Resource-Based view of the firm (NRBV) (Hart, 1995) is an influential theoretical framework for understanding how environmentally oriented resources and capabilities can yield sustainable sources of competitive advantage through its strategic interactions with the built and natural environments (e.g., Makhloufi, Laghouag, Meirun, & Belaid, 2022; Mishra & Yadav, 2021). While the NRBV provides theoretical mechanisms (e.g., pollution

[1] Biodiversity refers to '*the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part. This includes diversity within species, between species and of ecosystems*' (IPBES, n.d.).

prevention, product stewardship, and sustainable development) connecting environmental capabilities to competitive advantage, its applications have largely remained firm- and efficiency-centric approaches, focusing on the firm's internal capabilities to effectively deploy resources for competitive advantage (Hart & Dowell, 2011). When applied to sustainability and particularly to biodiversity, the NRBV's firm-centric and instrumental treatment of nature collapses ecological complexity into a generic 'natural environment', neglecting biodiversity as a relational and systemic phenomenon. This reliance on firm-level, efficiency-centric capabilities can lead firms to overlook the dynamic and networked nature of the broader social-ecological systems in which firms operate, including cross-scale feedback loops and landscape-level impacts of business activities. As a result, firms may underestimate their exposure to biodiversity-related risks and inadvertently undermine their own long-term resilience (Giglio et al., 2023).

Moreover, the NRBV remains conceptually underdeveloped in relation to biodiversity. It offers little guidance on when biodiversity–related interventions become strategic assets or how firms should evaluate ecosystem-specific investments (Whiteman,Walker, & Perego, 2013). This blind spot reflects the NRBV's limited specification of mechanisms: it overlooks the ecological, relational, and institutional pathways through which biodiversity actions translate – or fail to translate – into competitive outcomes. These limitations are amplified by the narrow empirical focus on pollution prevention and manufacturing contexts. Such settings differ from land-intensive renewable infrastructures where biodiversity outcomes unfold across landscapes and are shaped by intricate regulatory architectures and contractual interdependencies.

In parallel, scholars increasingly call for integrating biodiversity into business strategies not merely as a resource to be offset but as a dynamic and regenerative asset (Bansal, Durand, Kreutzer, Kunisch, & McGahan, 2025; Boiral & Heras – Saizarbitoria, 2015; Carton & Parigot, 2024; Gibassier, Mass, & Schaltegger, 2019; Kalhoro & Kyaw, 2024; Nedopil, 2023; Panwar, 2023; Schaltegger et al., 2023; Winn & Pogutz, 2013). Yet despite this growing attention, biodiversity research in businesses remains fragmented, lacking an integrated theoretical framework to extend insights across industries and sectors (Panwar et al., 2023). Panwar and colleagues (2023) point out that this fragmentation is further exacerbated by the flawed presumption that scientific guidance alone is sufficient for firms to implement timely and effective biodiversity strategies – an assumption that constrains the field's perceived theoretical development. Consequently, firms relying on conventional NRBV logics risk narrowing the strategic perspective and may overlook emerging nature positive opportunities while misjudging material biodiversity-related risks (e.g., Blaydes, Potts, Whyatt, & Armstrong, 2021; Hahn & Tampe, 2021; Randle-Boggis et al., 2020).

Taken together, these limitations reveal that existing NRBV scholarship is insufficient to explain how biodiversity-oriented capabilities emerge, interact, and shape competitive outcomes in land-intensive, multi-actor contexts. To address this, we employed a qualitative inductive approach to investigate how firms conceptualise and operationalise biodiversity-related strategies, examining both the micro-foundations of biodiversity-oriented capabilities and the broader inter-organisational collaborations (Bag & Rahman, 2024; Eisenhardt & Martin, 2000; Khanra et al., 2022; You & Williams, 2023). We conducted in-depth semi-structured interviews with nine purposefully selected firms operating across the UK solar farm value chain. This empirical setting presents a unique and underexplored context where land-use impacts, habitat fragmentation, and ecological trade-offs are often substantial (Blaydes et al., 2025; Froidevaux et al., 2024; Gasparatos et al., 2017; Lafitte et al., 2022; Rehbein et al., 2020; Santangeli et al., 2016). The sector is further shaped by England's rapid solar development targets and the legal introduction of a mandatory 10% Biodiversity Net Gain (BNG) to be achieved either directly onsite or through purchasing credits for all new developments (UK Government, 2023 a, 2023b). Within this regulatory and ecological landscape, firms face growing environmental constraints and stakeholder pressures. To corroborate and enrich the emerging findings, we reviewed over 1000 pages of industry reports and policy documents and facilitated in-person focus groups with 24 professionals in London.

Through this multi-step analysis, we identified five core inter-firm activities: ***investor relations management (IRM), strategic and operational management (SOM), biodiversity and nature-positive initiatives (BNI), collaboration and community impact (CCI) and policy engagement and compliance (PEC)***. These activities were not only central to firm's strategic positioning but also reflected distinct yet interconnected biodiversity value orientations: ***instrumental, integrative and ecosystem-based*** **value propositions**. These orientations shaped, and were shaped by, inter-firm dynamics, illustrating the ways in which biodiversity considerations are embedded in business strategy, governance practices and stakeholder relations across the sector.

Our study makes several contributions. Firstly, we advance the NRBV by conceptualising biodiversity as a structuring social-ecological mechanism that shapes how environmental capabilities link to strategic value. Much NRBV scholarship assumes the natural environment as a broad and largely undifferentiated context, with value creation explained mainly through firm-level efficiency gains or cost reductions. Our findings show that biodiversity plays a more active role, influencing the interactions, constraints, and opportunities firms encounter across multi-actor solar farm value chains. This perspective broadens the NRBV's underlying assumptions by shifting from a firm centric view of resource management toward a relational, ecosystem-based understanding where biodiversity influences strategy through its material, regulatory, and landscape-level dynamics.

Secondly, we contribute to the NRBV by explaining how biodiversity, traditionally viewed as a public good, is transformed into a strategic and regenerative asset through distinct biodiversity-oriented strategic orientations. We identify three biodiversity-oriented strategic orientations – instrumental, integrative, and ecosystem-based – that capture the different logics through which firms engage with biodiversity. These orientations shed light on multiple pathways for biodiversity value creation, each associated with specific capability requirements, coordination challenges, and governance tensions. By distinguishing these orientations, we clarify the strategic conditions under which biodiversity-related investments become sources of competitive advantage, moving the NRBV beyond its traditional focus on efficiency-driven capabilities toward a more nuanced account of nature positive strategy.

Thirdly, we broaden the empirical boundary conditions of the NRBV by examining a setting where biodiversity is materially and strategically significant: land-intensive renewable energy infrastructures embedded in complex regulatory and contractual arrangements. Prior NRBV research has predominantly examined manufacturing and pollution-prevention contexts–environments in which biodiversity plays a limited role and ecological interdependencies are minimal. By studying the UK solar sector – shaped by mandatory Biodiversity Net Gains (BNG), landscape-scale ecological considerations, and multi-stakeholder governance– we demonstrate strategic dynamics and capability developments that do not surface in conventional

NRBV settings. This boundary-condition extension demonstrates that environmental capabilities evolve differently within highly institutionalised socio-ecological systems, where biodiversity is not peripheral but central to planning decisions, licensing, legitimacy, and long-term value creation. As such, our study expands the applicability of the NRBV to emerging nature positive industries and highlights the need for theory to account for ecological interdependence, spatial constraints, and regulatory complexity.

2. THEORETICAL BACKGROUND AND LITERATURE REVIEW

2.1 Biodiversity and Strategic Management

Biodiversity is a multifaceted concept that is defined and operationalised in various ways within management and strategic frameworks. At a fundamental level, biodiversity refers to the variety of life at different levels, from genes to ecosystems, and is crucial for maintaining ecosystem services and stability (Cairns & Lackey, 1992; Coleman, 1996). Research on biodiversity-ecosystem functioning (BEF) demonstrates that species richness and functional diversity underpin ecosystem services, adaptive capacity and long-term ecosystem viability (Tilman,1999; Duffy et al., 2017). These insights highlight biodiversity not merely as a peripheral environmental attribute but as a structuring biophysical mechanism shaping the constraints and opportunities available to organisations.

In management and organisation studies, biodiversity has increasingly been recognised as a material strategic concern. Recent work on biodiversity corporate strategy and accounting frames biodiversity loss as a critical, non-substitutable risk requiring firms to embed commitments across operations and supply chains, adopt preventive and restorative strategies, and strengthen accountability (Kalhoro & Kyaw, 2024; Nedopil, 2023; Panwar, 2023; Panwar et al., 2023). Empirical evidence shows that higher biodiversity disclosure is positively associated with firms' financial performance (return on assets) (Elsayed, 2023). Parallel developments in natural capital and nature-related disclosure frameworks emphasise biodiversity as a core component of ecosystem assets (Taskforce on Nature-related Financial Disclosures, 2023).

Biodiversity is increasingly operationalised through decision-making frameworks that align corporate planning with planetary boundaries (Edwards, 2021;

Hahn & Tampe, 2021; Schmeller et al., 2017; Smith et al., 2020). Management tools such as Environmental Management Systems (EMS), Environmental Management Accounting (EMA) and Life Cycle Assessment (LCA) help institutionalise biodiversity considerations within performance evaluation and operational routines (Gunarathne, Lee & Hitigala Kaluarachchilage, 2020; Tsalis et al., 2020; Xu et al., 2024). Leadership values and organisational identity further shape how biodiversity is interpreted and prioritised influencing strategic sensemaking and action (Angus-Leppan, Benn, & Young, 2010; Montiel, Gallo, & Antolin-Lopez, 2020; Stefanelli et al., 2021). Biodiversity is also being incorporated into dynamic capabilities through sensing, seizing, and reconfiguring (Dressler, 2023; Liboni et al., 2023), and into business model innovation aimed at ecological regeneration (Bocken & Geradts, 2020; De Angelis, 2022).

Despite these advances, biodiversity remains conceptually fragmented within strategic management discourse (Aragon-Correa & Marcus, 2020; Bansal & Song, 2017; Boiral & Heras–Saizarbitoria, 2015). Tools and metrics have proliferated, yet the underlying mechanisms through which biodiversity structures firm-stakeholder interactions and multi-actor governance remain under developed. Scholars in the ‘business and ecosystem’ tradition argue that firms are embedded within ecological systems, which challenge firm-centric ontologies (Starik & Randsm, 1995; Winn & Pogutz, 2013). Planetary boundaries research similarly identifies biodiversity as a a systemic threshold whose transgression undermines the stability conditions upon which firms rely (Rockström et al., 2009; Whiteman, Walker & Perego, 2013).

Insights from social-ecological systems (SES) literature further emphasise that ecological processes and social institutions co-evolve within interdependent systems characterised by feedback loops and multi-actor governance (Ostrom, 2009; McGinnis & Ostrom, 2014). From an SES perspective, biodiversity is not simply as an environmental impact, but as a fundamental organising force structuring interdependencies, trade-offs and strategic interactions across value chains. Integrating BEF, SES and business-ecosystem insights reveal a theoretical misalignment: where ecological science conceptualises biodiversity as a structuring mechanism, strategic management – particularly the NRBV – treats nature as a generic external domain. This misalignment limits our understanding of how biodiversity shapes organisational behaviour and strategic outcomes. It provides the foundation for revisiting and extending the NRBV.

2.2 Natural-Resource-Based View (NRBV) and Biodiversity

Hart's (1995) NRBV argues that firms achieve sustained competitive advantage by developing capabilities aligned with environmental sustainability through pollution prevention, product stewardship and sustainable development. This framework has strongly influenced environmental strategy research, yet biodiversity plays only a peripheral role in its evaluation.

2.2.1 Core Assumptions of the NRBV

NRBV research has generally relied on several implicit assumptions about how firms derive competitive advantage from environmental engagement. At a general level, the natural environment is treated as an undifferentiated and external domain of constraints and resources; environmental capabilities are conceptualised primarily as firm-level capabilities emerging within firm boundaries; competitive advantage is assumed to derive from efficiency, stewardship or clean technology rather than from ecological dynamics themselves; and environmental challenges are framed as firm-environment interactions rather than as relational, spatially distributed or multi-actor processes (Christmann, 2000; Russo & Fouts, 1997; King & Lenox, 2001; Hart & Dowell, 2011). These assumptions are embedded within the three pillars of the NRBV. Pollution prevention assumes that firms gain advantage by minimising waste and emissions through efficiency improvements (Hart, 1995). Product stewardship assumes that firms can differentiate themselves by managing environmental impacts across the product lifecycle, which therefore appeal to environmentally conscious stakeholders. Sustainable development assumes that aligning operations with long-term ecological sustainability secures future resource availability and regulatory legitimacy. These assumptions reflect the empirical contexts that have shaped most NRBV research, such as manufacturing, pollution-intensive and process-engineering industries, where biodiversity plays a limited material or strategic role.

2.2.2 Why Biodiversity Challenges NRBV Assumptions

Insights from ecology, conservation and ecological economics demonstrate that biodiversity is a core component of natural capital, and therefore foundational to public and private benefits from ecosystem functioning. Three areas are especially important. Firstly, biodiversity introduces material ecological dynamics, such as species-specific habitat requirements, ecological thresholds and temporal cycles (e.g., Blaydes et al., 2025; Cardinale et al., 2012; Duffy et al., 2017; Froidevaux et al., 2024; Gómez-Catasús et al., 2024; Tilman et al., 1999; Rehbein et al., 2020), which directly constrain land use, infrastructure design and operational practice. Such dynamics are complex and sometimes unpredictable, which cannot be simply reduced to process optimisation or efficiency improvements. Secondly, biodiversity is increasingly embedded in regulatory and institutional frameworks, such as the UK's mandatory Biodiversity Net Gain (BNG) (UK Government, 2023a, 2023b; DEFRA, 2023), which impose long-term monitoring, planning and compliance obligations. These pressures shift biodiversity management from a voluntary environmental initiative to a material strategic issue shaped by both longstanding ecological regulations (such as protected species requirements with planning) and new governance and financial disclosure obligations that require firms to assess, manage and report their biodiversity impacts an d dependencies. and governance and financial disclosure. Thirdly, biodiversity operates across landscape-level ecological interdependencies, requiring coordination among multiple actors – including regulators, landowners, communities and ecological experts – and generating feedback loops between ecological processes and social institutions (e.g., Bodin, 2017; Folke et al., 2015; Kremen & M'Gonigle, 2015; McGinnis & Ostrom, 2014; Ostrom, 2009; Schmeller et al., 2017; Whiteman et al., 2013). Such spatial and relational interdependencies contradict the NRBV's view of nature as a generic, external domain and its focus on firm-level capability development.

Thus, these ecological, institutional and spatial dynamics illustrate that biodiversity is not merely an environmental attribute to be managed but a structuring social-ecological mechanism that shapes capability needs, value creation and strategic action. This misalignment in the NRBV's treatment of nature becomes particularly evident in biodiversity-dependent sectors, such as land-intensive solar energy, where biodiversity materially influences siting decisions, planning permissions, legitimacy and long-term operational obligations (Armstrong et al., 2016; Blaydes et al., 2025; Carvalho et al., 2024; Gómez-Catasús et al., 2024; Rehbein et al., 202; Roddis et al., 2020). These dynamics highlight that ecological interdependencies operate across spatial and organisational boundaries – challenging the NRBV's assumption that environmental issues can be addressed through internal capabilities alone. This motivates the need to extend the NRBV by conceptualising biodiversity as a structuring mechanism, clarifying the strategic orientations through which firms respond biodiversity and revising the framework's boundary conditions for application in coupled social-ecological systems.

2.2.3 Re-examining the Three NRBV Pillar Through a Biodiversity Lens

The NRBV proposes three strategic pathways through which firms develop environmental capabilities – pollution prevention, product stewardship and sustainable development (Hart, 1995). While these pillars have guided decades of research, biodiversity introduces dynamics that challenge their underlying assumptions.

Pollution Prevention. Pollution prevention focuses on reducing waste and emissions at the source to enhance resource efficiency and reduce ecological harm (Hart, 1995). Incorporating biodiversity considerations can strengthen these efforts, as limiting pollutants such as chemicals, plastics and wastewater directly supports species and habitat conservation (Sigmund et al., 2023). Tools such as Environmental Management Systems, biodiversity indicators and ESG frameworks help firms embed ecological concerns into daily operations (Leoni, 2025; Schmeller et al., 2017; Smith et al., 2020). However, the NRBV's pollution prevention logic rests on the assumption that capabilities arise primarily within organisational boundaries and that internal efficiency gains can secure competitive advantage. Biodiversity challenges this assumption because many biodiversity outcomes depend on habitat continuity, species mobility and ecological thresholds that firms can not manage unilaterally. Pollution controls, while important, are insufficient for building biodiversity-related capabilities. Managing biodiversity risk requires forms of coordination, monitoring and ecological stewardship that extend beyond the firm and beyond the internal-efficiency focus of the pollution prevention pillar.

Product Stewardship. Product stewardship extends responsibility across the product lifecycle (Hart, 1995) and seek to reduce impacts embedded in supply chains and material extraction (Harsanto, Kumar, & Michaelides, 2024; Crenna et al., 2020). Traceability systems, certifications and life-cycle assessments increasingly link production practices with the ecological impact (Carton & Parigot, 2024; Jell-

Ojobor & Raha, 2022; Winter et al., 2017). Policy instruments such as Extended Producer Responsibility (EPR) further incentivise upstream innovation and circular economy practices that indirectly benefit biodiversity (Cai & Choi, 2019; Degenstein et al., 2023; Domenech & Bahn-Walkowiak, 2019; Kunz, Mayers, & Van Wassenhov, 2018). Yet, biodiversity impacts typically arise from landscape-level ecological processes, not discrete stages of a supply chain. These impacts depend on coordination among regulators, land managers, local communities and conservation organisations – actors often outside the remit of product stewardship tools. Lifecycle approaches cannot fully address ecological feedback loops or cross-boundary processes (e.g., species dispersal, cumulative habitat disturbance). As such, stewardship that focuses on supply-chain control risks overlooking ecological dynamics that shape biodiversity outcome.

Sustainable Development. The third pillar of Hart's NRBV — sustainable development — emphasises long-term investments and innovation that align firm growth with ecological and social sustainability (Hart, 1995). Regenerative business models, including agrivoltaics and bioeconomy initiatives, show how firms can generate financial returns while enhancing ecosystems and local resilience (Ahenkora, 2025; Bocken & Geradts, 2020; Carton & Parigot, 2024; De Angelis, 2022; Lacey-Barnacle et al., 2023; Roddis et al., 2020). Financial innovation such as green finance and impact investing further support long-term ecological innovation by directing capital toward environmental regeneration (Liang, 2024). However, biodiversity complicates the sustainable development pillar in ways that the NRBV does not fully anticipate. Land-intensive sectors now face mandatory biodiversity-related obligations, including Biodiversity Net Gain (BNG) requirements and increasingly stringent nature-related financial disclosure frameworks (e.g., TNFD, ISSB). These instruments create material financial risks and opportunities tied to how owned or managed land is stewarded for biodiversity – affecting asset valuation, access to capital, land-use permissions and long-term liability exposure. As a result, sustainable development cannot rely solely on internal innovation or voluntary initiatives; it must engage with landscape-level ecological planning, inter-organisational collaboration and social-ecological feedback processes that extend beyond the firm. This positions biodiversity as a strategic mechanism that foregrounds the need for capabilities that navigate regulatory obligations, spatial planning requirements and wider social-ecological feedback.

Revisiting the NRBV pillars through a biodiversity lens shows that the framework continues to treat the natural environment as a generic external domain, rather than as a differentiated ecological system characterised by spatial interdependence, regulatory complexity and multi-actor coordination. As a result, they do not fully account for how biodiversity materially shapes land use, long-term obligations, stakeholder negotiations and strategic value creation. This gap highlights the need to consider how firms interpret and respond to environmental complexity.

2.2.4 Environmental Strategy and Organisational Responses to Environmental Issues

Environmental strategy research shows that firms adopt heterogeneous responses to environmental challenges. Scholars distinguish between reactive, compliance-driven approaches and proactive strategies based on innovation, learning and stakeholder engagement (Sharma & Vredenburg, 1998; Aragón-Correa & Sharma, 2003). Firms' environmental actions are influenced by diverse motives – competitiveness, legitimacy and ecological responsibility – which shape how environmental issues are prioritised (Bansal & Roth, 2000). Sustainability paradox research further highlights persistent tensions between short-term efficiency and long-term ecological regeneration in complex ecological contexts (Hahn et al., 2015). Together, this work demonstrates that firms develop distinct strategic logic when responding to environmental issues and that these logics are shaped by how organisations interpret risks, responsibilities and opportunities. However, despite growing interest in nature-related risk and disclosure, biodiversity remains underdeveloped within this literature. Its spatial interdependencies, ecological feedback loops and multi-actor governance requirements suggest that biodiversity may give rise to strategic orientations that are different from other environmental issues. This gap provides the theoretical foundation for examining biodiversity-specific strategic orientations and motivates the need to study biodiversity-dependent contexts such as land-intensive renewable energy.

2.3 Renewable Energy and Biodiversity

Renewable energy is a critical mitigation strategy for climate change – a key driver of biodiversity loss that represents an equally urgent crisis (Gasparatos et al., 2017; Pörtner et al., 2021). However, the relationship between renewable energy and biodiversity is complex, involving both synergies and trade-offs (Angus-Leppan et al., 2010; Carvalho et al., 2024; Edwards, 2021; Santangeli et al., 2016). Land-intensive renewable infrastructure operates within complex social-ecological systems (SES), where ecological processes and socio-political institutions are tightly intertwined (Ostrom, 2009; Folke et al., 2010). In these contexts, biodiversity becomes a material and strategic variable, influencing siting, planning permissions, licensing, local legitimacy and long-term management obligations. These characteristics differ markedly from the manufacturing contexts typical in NRBV research and make renewable energy a highly relevant setting for extending NRBV boundary conditions.

2.3.1 Synergies and Benefits

Renewable energy can generate important biodiversity-related benefits. By reducing greenhouse gas emissions, they mitigate climate-driven ecosystem disruptions, including habitat shifts, species loss and extreme weather risks (Gasparatos et al., 2017; Santangeli et al., 2016). Broader societal benefits – innovation, employment and energy security – may also indirectly support conservation and local adaptive capacity (Weng, 2024). Community renewable energy initiatives illustrate how participatory governance can create environmental, social and educational co-benefits (Klein and Coffey,2016). These synergies underscore the potential of renewables to contribute to both decarbonisation and biodiversity protection when strategically designed and managed.

2.3.2 Trade-Offs and Challenges

Despite these benefits, large-scale renewable energy systems can generate ‘green–on–green’ tensions when climate mitigation goals conflict with local ecological conservation (Roddis et al., 2020). These tensions arise because biodiversity impacts are shaped not only by technical design choices but also by divergent stakeholder interpretations of what constitutes sustainability, as emphasised by Angus-Leppan et al’s (2010) sensemaking perspective. Their work – and subsequent research building on it (Benn et al., 2013) – shows that trade-offs often emerge from differences in how actors prioritise human, ecological and economic values. In renewable energy contexts, such interpretive differences become particularly pronounced during siting, permitting and mitigation planning, where communities, regulators, conservation groups and developers frame risks and benefits through competing mental models. Ecologically, large-scale renewable energy systems can disrupt habitats through land conversation, fragmentation and altered microhabitat conditions (Armstrong et al., 2016; Gómez-Catasús et al, 2024; Rehbein et al., 2020; Yang et al., 2024). Solar arrays and wind turbines can introduce species-specific hazards – such as bird and bat mortality through collisions (Froidevaux et al., 2024) or behaviour changes among reptiles and small mammals (Lafitte et al., 2023). Biodiversity impacts often arise from landscape-level processes, not simply through isolated firm-level actions or discrete supply-chain stages, highlighting forms of interdependence that the traditional NRBV does not readily capture.

2.3.3 Opportunities for Coexistence

While these trade-offs cannot be entirely avoided, there are opportunities to harmonise renewable energy expansion with biodiversity conservation, including strategic land management, wildlife-friendly design, context-specific management, standardised monitoring, and ecological restoration efforts (Blaydes et al., 2021; Blaydes et al., 2025; Carvalho, Healing, & Armstrong, 2024; Virtanen et al., 2022). Deploying solar and wind infrastructure, especially when sited outside areas of high conservation priority — such as brownfields, industrial sites, or arid zones with limited ecological value — reduces ecological footprints (Montesino Pouzols et al., 2014; Santangeli et al., 2016). Hybrid approaches, such as agrivoltaics that integrate solar PV infrastructure with conventional agriculture, can optimise land use efficiency, support synergies between sustainability goals (Dinesh & Pearce, 2016), and mitigate both plant drought and PV panel heat stress (Barron-Gafford et al., 2019). Integrating ecological assessment into land – energy planning, alongside rational spatial strategies, can enhance the sustainability of development by supporting both decarbonisation goals and ecosystem health (Yang et al., 2024).

3. METHOD

Given the context-sensitive nature of biodiversity strategies and the current conceptual fragmentation in strategic management literature, we employed a theory-informing inductive design (Varpio, Paradis, Uijtdehaage, & Young, 2020). This approach draws on the NRBV as an initial lens, while allowing the data to guide theoretical integration with interdisciplinary insights into how firms conceptualise and operationalise biodiversity. To advance understanding beyond a firm-centric perspective, we applied the Fuzzy Cognitive Mapping Approach (Özesmi & Özesmi, 2004; You, 2022) to visualise the dynamics of inter-firm activities and their role in shaping biodiversity value creation and capture across value chains.

3.1 Research Setting

Solar farms in England, which exemplify the land-energy-biodiversity nexus, offer a uniquely rich and timely context for investigating the intersection of biodiversity, strategic management and renewable energy. These ground-mounted solar farms are typically located on low-grade agricultural land, which presents both ecological risks and opportunities for regeneration through practices such as the creation of pollinator habitats and soil restoration (Blaydes et al., 2025; Carvalho et al., 2024). This dual impact on net zero and biodiversity makes solar farms an ideal empirical setting to explore how firms navigate ecological trade-offs and generate nature-positive business strategies. Additionally, solar farms are also subject to intense regulatory oversight. In England, for example, all new developments must comply with a legally mandated 10% Biodiversity Net Gain (BNG) – marking England as the first country to require measurable habitat enhancement for development projects (UK Government, 2023a, 2023b). The policy context aligns directly with the NRBV, which emphasises the role of environmental constraints and stakeholder pressure in shaping firm capabilities (Tsalis et al., 2020). Furthermore, the UK's solar sector includes a mix of organisational models and stakeholder networks – ranging from global utilities to local cooperatives – creating opportunities for comparative analysis of how firm size, governance structures, and stakeholder configurations affect biodiversity engagement and ecological innovation. The broader financial environment in the UK further reinforces the relevance of this context. Growing investor interest in ESG performance and green finance make solar farms as a strategic setting to explore how firms interpret, manage, and leverage biodiversity to achieve competitive advantage in a complex, regulation-driven, and opportunity-rich landscape.

3.2 Sampling Strategy and Data Collection

We employed a heterogeneous theoretical sampling approach (Eisenhardt & Graebner, 2007; Siggelkow, 2007), supported by collaboration with industry partners embedded in the UK renewable energy sector. These partnerships played a critical role in identifying and facilitating access to relevant organisations and key informants across the solar farm value chains. Specifically, we sought to include participants representing the core structure of the solar farm value chain in the UK, including investment, development, assets management, ecological consultancy, legal advisory, and community-led NGOs. These stakeholder groups were selected to ensure that our findings represent the functionally distinct and commonly involved actors responsible for shaping, financing, delivering, and stewarding solar energy projects across their lifecycle, and to capture a range of perspectives on how biodiversity is integrated into strategic and operational activities. In total, nine entities agreed to participate in the study (see Table 1).

Our study draws on several data sources collected during a broader investigation into the impact of biodiversity on businesses. It explores how firms engage with biodiversity as a strategic concern and how value chain interdependencies influence biodiversity outcomes. The data include: (a) qualitative data collected from semi-structured interviews; (b) archival data, including biodiversity frameworks and reports from industry, government and NGOs; (c) focus groups discussing biodiversity-related business practices. These varied sources provided triangulated data that enabled a rich understanding of both strategic intent and resource allocation towards biodiversity stewardship across the industry. This was further complemented by participant observations and regular meetings with industry partners to address gaps and validate emerging insights.

3.2.1. Interview Data

The interview protocol was co-developed with an industry partner, and designed to capture rich, contextual data to understand complex industry dynamics (Eisenhardt, 1989; Eisenhardt, Graebner, & Sonenshein, 2016). Eleven semi-structured interviews were conducted remotely in 2023 via video conferencing with senior managers (including the managing directors, operational director, vice presidents), business founders (where distinct from senior managers), and senior industry and environmental experts. These participants were selected to provide insights from key decision-makers involved in their firm's environmental strategy or biodiversity practices. Each interview, ranging from 45 to 60 minutes, was digitally recorded and fully transcribed. Participants were asked to describe their business's value chain and its interactions with the natural environment; alongside an examination of the opportunities and challenges they face in contributing to biodiversity outcomes within solar farm development.

3.2.2. Archival Data

We collected archival data through materials shared by industry partners and informants, including reports from government agencies, industry bodies, and NGOs, as well as other strategic documents relating to biodiversity-related plans, practices and strategies (over 1000 pages of documentation). These documents offer context-specific detail and historical depth that may not be fully captured through interviews alone, as they highlight broader biodiversity-related expectations, evolving regulatory frameworks and stakeholder demands. As such, the archival data offer an important complementary perspective, which helps understand how firms interpret, adapt to, and strategically respond to increasingly complex and dynamic environmental landscapes.

3.2.3. Other Sources

To corroborate and enrich the emerging findings, there was a series of focus groups conducted in-person at a dedicated industry workshop in London. These 90–minute sessions engaged in a total of 24 professionals representing a cross-section of roles in the solar farm value chains. The focus groups were designed to facilitate structured discussions on biodiversity-related practices within solar energy development. They provided real-time insights into how participants articulated and demonstrated their organisations' commitment to biodiversity, as well as the practical challenges and opportunities for collaboration they encountered. This format enabled the integration of sector-specific perspectives and supported the refinement of our research findings (Krueger & Casey, 2015; Morgan, 1996). Additionally, as part of a broader triangulation strategy, emerging insights were shared and discussed with industry partners to address potential gaps in the accounts and enhance the overall robustness of the study.

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3.3 Data Analysis

Our analysis followed the phenomenological procedures delineated by Sandberg's (2005) interpretive approach, supported by coding strategies from the Gioia methodology (Gioia, Corley, & Hamilton, 2013) and the Fuzzy Cognitive Mapping Techniques (Özesmi & Özesmi, 2004; You, 2022). The analytic process was iterative and interpretive, involving constant movement between the empirical data and theoretical frameworks to develop plausible explanations. We structured the analysis into three interconnected phases:

3.3.1. Phase One: Strategic Value Orientation

Our goal was to develop a general understanding of how participants perceive and define biodiversity value. We adopted a holistic approach to each interview transcript, focusing on how participants articulated their organisational needs, operational activities, and underlying values related to biodiversity. Through the iterative process of reading interview data, we identified three strategic orientations – instrumental, integrative and ecosystem-based – which reflect strategic positionings of biodiversity value within the NRBV framework (Bowman & Ambrosini, 2000; Hart, 1995). The instrumental orientation considers biodiversity in terms of the direct or indirect benefits it provides to the business, such as risk mitigation, compliance or profitability. Beyond treating biodiversity as means to an end, the integrative orientation regards it as a relational and social value that is woven into a firm's broader purpose in addition to its economic objectives. The ecosystem-based orientation recognises the intrinsic value of biodiversity and situates businesses as embedded within, and accountable to, natural systems. This conceptual framing provided an interpretive foundation for distinguishing variations in participants' understanding of biodiversity value and helped us classify their strategic orientation in relation to the three NRBV pillars: pollution prevention, product stewardship, and sustainable development.

More specifically, we conducted open coding of the interview transcripts to identify how biodiversity value was expressed in practice. Coding categories emerged inductively, informed by repeated readings of the text and comparative analysis across cases. Through iterative refinement processes, across three researchers independently reviewing the documents and coding, we collectively consolidated and organised first-order concepts into second-order themes, which are grouped into three theoretical aggregate dimensions: instrumental, integrative and ecosystem-based orientation (Gioia et al., 2013) (see in Figure 1)

INSERT FIGURE 1 HERE

3.3.2. Phase Two: Inter-firm Activity and Influence Analysis

To understand how biodiversity is operationalised within the solar energy sector, we conducted an intensive, fine-grained reading of interview data. We began with a visual mapping exercise (Casadesus-Masanell & Ricart, 2010; Langley, 1999), focusing on key actors and their key strategic activities, measured by the flow of resources and information and the value created (Cao et al., 2018) across the solar farm value chain. Developing these structural maps was a highly iterative process that helped us to understand the type of actors each organisation was connected to and how the organisation transformed inputs into outputs to create value. Following the logic of inductive research, we used open coding to the interview data, initially identifying discrete activities. These were gradually refined into first-order categories, which were then consolidated into 19 second-order themes. This process culminated in five overarching inter-firm activity themes: *investor relations management (IRM), strategic and operational management (SOM), biodiversity and nature-positive initiatives (BNI), collaboration and community impact (CCI)* and *policy engagement and compliance (PEC)* (See Table 2). These themes represent distinct yet interconnected domains where biodiversity value is either embedded or contested across the value chain. To explore the dynamic relationships between these activities, we employed a fuzzy cognitive mapping (FCM) technique (Özesmi & Özesmi, 2004; You, 2022), which allowed us to identify how biodiversity values are understood, enacted, and negotiated across firm boundaries (See Figure 2).

INSERT FIGURE 2 HERE

INSERT TABLE 2 HERE

3.3.3. Phase Three: Synthesising Value with Challenges, Opportunities and Tensions in Inter-firm Activities

The final phase of our analysis synthesised firms' biodiversity-related activities and biodiversity value orientations (see Table 3). Following Gioia et al.'s coding method (2013), we identified three aggregated constructs: challenge, opportunity and tension, which we then mapped each value orientation, based on the value coding framework developed in Phase One (see Table 4).

INSERT TABLE 3 HERE

INSERT TABLE 4 HERE

4. FINDINGS

4.1 Biodiversity Value Orientation

4.1.1. Instrumental Orientation

Reputation Associated Competitive Advantage. Biodiversity commitments are now powerful tools for market differentiation, client retention, and enhancing organisational appeal in ESG-sensitive contexts. Firms operating in the solar and broader renewable sectors increasingly showcase their contributions to environmental health as part of their bid or investor narrative, helping firms stand out in tender evaluations:

> *Clients are increasingly highlighting their contributions to biodiversity and environmental health…helping improve their ESG profile (NPF – 5)*

In the ESG-driven market, businesses are actively adapting service lines and ecological enhancement strategies in response to client requests – particularly among asset managers and solar developers with ESG mandates:

Our approach to nature-positive initiatives is largely client-driven…Clients usually approach us with a desire to improve biodiversity or solve a biodiversity problem (NPF – 6).

Equally important, robust nature-positive data and reporting help mitigate reputational risk – especially around greenwashing – by demonstrating credible, measurable impact rather than mere marketing claims. One firm tailored its biodiversity and nature-positive policy statements to avoid losing in ESG-heavy tenders (NPF – 10). This demonstrates how ESG credentials in tenders are not only a compliance necessity but a tactical advantage.

Investment Mobilisation. Beyond reputation, biodiversity assets themselves are becoming recognised through financial instruments that unlock new pools of capital – particularly from institutional investors. These investors now seek mechanisms that deliver measurable value:

Investors are interested in whether there are mechanisms like biodiversity credits that can provide tangible value, similar to how carbon credits work (NPF – 4).

Responding to this demand, firms have begun weaving biodiversity metrics into capital structures. Green bonds and securitisations now increasingly feature nature-tied financial products, while bespoke financing vehicles offer reduced interest rates or equity adjustments when specific habitat-enhancement targets are met. For instance:

We help design financial structures that incentivise sustainable practices, such as reduced interest rates or changes in equity structures for achieving nature-positive outcomes (NPF – 11).

At the same time, tradable ecosystem assets, including biodiversity, water and carbon, are emerging as mainstream tools. These instruments enable measurable return and allow risk to be spread more broadly across multiple actors, which transform biodiversity from a compliance cost into a diversified investment pillar. The payoff is clear: funds that transparently demonstrate nature-positive performance gain a competitive advantage. As one fund manager noted,

Investment memoranda for solar parks now include details on environmental soundness and nature-positive aspects, which have become crucial selling points (NPF – 11).

Another interviewee added,

> *Nature positivity will become increasingly prominent and serve as a key differentiator for companies seeking capital (NPF – 5).*

This strategic framing of biodiversity not only attracts ethical investors but also builds resilience into long-term asset valuation by aligning long-term financial performance with the shifting market norms of sustainable markets.

Regulatory Advantage. In the face of tightening environmental disclosure regimes and mandatory Biodiversity Net Gain (BNG), firms are increasingly leveraging biodiversity initiatives as a strategic means to navigate legal complexity and manage regulatory risk. Rather than waiting for enforcement actions, leading organisations embed biodiversity requirements into their core operations and investment decisions:

> *We are responsible for drafting legal agreements and negotiating agreements related to habitat mitigation and BNG requirements, expecting a substantial workload due to active legal involvement in these negotiations (NPF – 8)*

This proactive approach shifts legal work on biodiversity from a reactive afterthought to an integral part of early-stage planning and risk mitigation. By standardising contractual frameworks – such as conservation covenants, biodiversity credit agreements, and tailored lease options – companies create clear, reputable structures for meeting BNG obligations while opening avenues for monetisation and long-term stewardship. As another respondent noted:

> *The team is actively working on creating a suite of documents, including conservation covenants and options and leases related to BNG land. These documents will be foundational for negotiations on various development sites (NPF – 10)*

By investing early in these legal instruments, firms simplify future transactions, reduce uncertainty, and strengthen their ability to negotiate favourable terms with planners, investors, and landowners. In doing so, they turn regulatory alignment into a source of market leadership – using biodiversity governance to streamline due diligence, build stakeholder trust, and unlock new commercial pathways through emerging biodiversity markets.

Operational Efficiency. Nature-positive practices are increasingly being integrated into solar and land management strategies as a means to reduce costs and enhance operational performance. Leading firms now view ecological enhancement not only as a sustainability obligation but as a driver of cost savings. As a solar operator noted,

> *…guidance on how to manage sites efficiently leads to cost savings by reducing the need for intensive agricultural practices and promoting sustainable land use…there is [also] potential cost saving associated with less intensive management... (NPF – 7).*

These insights show how biodiversity-friendly operations can reduce inputs such as fertilisers, irrigation, or mowing – all while supporting regulatory compliance and advancing ecological outcomes.

Resource efficiency also emerges through adaptive land use planning and ecological design and management principles:

> *Solar panels can inadvertently create beneficial conditions for certain types of vegetation and wildlife…these microhabitats imply the need to consider them in ecological planning and management (NPF – 7).*

Recognising and harnessing these synergies helps operators minimise remediation costs and optimise land use throughout a project's lifecycle.

Additionally, firms are monetising ecological co-benefits through Payment for Ecosystem Services (PES) models, further reinforcing the instrumental value of biodiversity. As one participant noted,

> *If biodiversity credits have a monetisable value, they are factored into the DCF [Discounted Cash Flow], enhancing the investment's overall value (NPF – 4).*

Another added,

> *A solar farm engaging additional environmentally friendly activities on-site could generate additional revenue (NPF – 9)*

Thus, embedding PES frameworks into financial models simultaneously advances ecological goals and enhances revenue resilience.

4.1.2 Integrative Orientation Value

Biodiversity is seen as part of an integrated socio-ecological system – where ecological and social systems are co-dependent. These values embed nature within business identity, governance, operations, stakeholder relationships or long-term resilience strategies.

Organisational Alignment and Strategic Integration. Leading organisations embed biodiversity not as an add-on, but as a core value that shapes culture and vision:

> *The primary purpose for me and for everyone in the firm is to be doing the right thing for the environment … it's what motivates us every day (NPF –10).*

This guiding principle is formalised through CSR frameworks that explicitly include biodiversity targets alongside net-zero and ethical investment goals:

> *Our firm voluntarily reports on biodiversity progress alongside carbon metrics, even when not legally required. It sets a tone of accountability* (NPF–9).

That internal focus also guides bespoke ESG solutions for clients:

> *We're working with clients to understand how biodiversity fits into their ESG strategy — it's not a one-size-fits-all. The key is to align impact with purpose* (NPF–5).

Operational Integration and Adaptive Management. Biodiversity is not treated as an isolated intervention but as a foundational element of planning, site design, and operational practice. From the outset, detailed planning frameworks, such as Landscape and Ecological Management Plans (LEMPs) or Construction Environmental Management Plan (CEMP) make biodiversity a binding project requirement:

> *LEMPs and CEMPs are critical tools — they ensure that biodiversity is not an afterthought but factored into land management and site operation from the start (NPF–7).*

These documents hold clients and contractors accountable, embedding ecological goals alongside energy and engineering priorities. During construction and operation, even infrastructure design leverages ecological synergies:

> *The way the panels shade certain areas creates specific growing conditions that benefit different species ... it's an opportunity to design with biodiversity in mind* (NPF–7).

Rather than implementing a one-off plan, management is continually refined through monitoring and feedback. Teams use site-specific data to adapt practices in real time:

> *We're learning as we go — adjusting our mowing regimes, habitat enhancements, and even signage based on what the monitoring tells us* (NPF–6).

Finally, this integrative approach extends to end-of-life planning. Developers build in long-term stewardship commitments to ensure that restored ecosystems endure:

> *We've already factored in end-of-life scenarios where the land either reverts to previous use or is maintained for ecological benefit. It's about leaving a legacy, not just ticking a compliance box* (NPF–11).

By embedding biodiversity from inception through decommissioning – and by continuously adapting based on ecological feedback – organisations ensure that solar farm projects deliver durable, landscape-scale conservation outcomes.

Stakeholder Engagement and Co-production. Biodiversity outcomes are improved when local voices shape both design and delivery. Partnering with those who live on, use or manage the land brings local knowledge to biodiversity planning:

> *Working with various stakeholders, including developers, local authorities, and conservation organisations, ensures that diverse perspectives are considered in ecological planning. Collaborative efforts lead to more inclusive and sustainable outcomes that benefit a wider range of stakeholders* (NPF – 7)

This approach extends to landowners. Involving farmers early on–through guidance and training – grounds restoration measures in practical reality and builds trust:

> *Educating farmers who have leased their land to solar arrays about the importance of biodiversity management can foster better compliance with management plans and improve ecological outcomes* (NPF – 7).

By raising ecological understanding through two–way knowledge exchange, it empowers communities to become active stewards. Teams conduct '*community activities like bat presentations and environmental education sessions to raise awareness and interest in ecology among children and the broader community'*, and '*support local schools through training sessions and educational programmes'* (NPF – 7). Beyond this, sharing monitoring data and lessons learned with academic partners '*enhances environmental science and provides educational opportunities'*, creating a feedback loop where community observations inform research and vice versa (NPF – 7). This co-learning builds local capacity to understand, value, and protect biodiversity long after initial projects conclude.

Embedding participatory monitoring ensures continuous improvement. Practitioners '*collaborate with ecological stakeholders for guidance that is based on practical experience and evidence, such as the installation of a camera box to monitor the owls'* (NPF – 2) and undertake '*ongoing monitoring of operational sites to* *assess habitat conditions, species usage, and the effectiveness of ecological enhancements*' (NPF – 7). Importantly, these findings are shared across sectors: '*Collaborating with other sectors to share best practices and develop unified standards can enhance the overall effectiveness of sustainability initiatives*' (NPF – 9). By engaging stakeholders in data collection and reflection, management plans evolve in real time – maximising ecological gains and fostering a culture of collective learning.

Social Legitimacy and Sustainability Leadership. Organisations that pioneer biodiversity integration through nature-positive practices not only establish themselves as industry leaders but also shape industry norms. Early adopters serve as living case studies, showing what's possible when renewable energy and nature conservation work hand-in-hand. As one participant highlighted,

> *[company] has been actively running biodiversity enhancement schemes like UBMP and EXEMPLAR for three years, focusing on ecological improvements across solar sites. The EXEMPLAR project, covering eight sites since 2017, experiments with various land management methods to enhance biodiversity, showcasing how solar energy and nature conservation can coexist (NPF – 2)*

By investing resources in these pilot schemes, first-movers provide tangible proof that nature-positive measures are feasible at scale – encouraging regulators, investors, and peers to embrace similar approaches and helping to set the agenda for future best practice.

Furthermore, credible, participatory biodiversity action earn social licence to operate by reducing opposition and smoothing the path to project approval. When local stakeholders see real, measurable environmental gains, opposition falls and social licence strengths. As stated,

Demonstrating environmental improvements to local communities and stakeholders helps to gain their support in securing project consents, reducing opposition, and fostering positive community relations (NPF – 10)

However, public attitudes can remain nuanced: *'The general public is increasingly supportive of renewable energy, but often resistant to living near solar plants. As renewable energy expands and begins to encroach on more populated areas, offering additional societal benefits (beyond just energy generation) could enhance public acceptance'* (NPF – 1). Embedding habitat creation, educational programmes, and open monitoring into project design not only addresses these concerns but also transforms sceptics into advocates – reinforcing both legitimacy and long-term success.

4.1.3 Ecosystem-Based Orientation Value

Regenerative Purpose. Nature is valued for its intrinsic worth, which is independent of direct or indirect human use, and hence market value. When businesses embrace this intrinsic appreciation, they acknowledge a moral duty that drives all regenerative action, prioritising long term ecological health over short-term gain:

> *Our principal motivation is intrinsic, driven by a shared desire among like-minded ecologists to achieve better ecological outcomes. We focus on doing the right things rather than marketing our services. Operating without debt or shareholders allows us to prioritise our principles over profit* (NPF–7)

This ethos transcends individual firms:

> *The primary purpose for me and for everyone in the firm is to be doing the right thing for the environment* (NPF – 10)

–and has become an industry-wide ethos in the sector of renewables:

> *Many individuals in the solar industry, including engineers and financial experts, have chosen this field not just for economic benefits but due to a genuine belief in renewable energy and a desire to contribute positively.* (NPF – 11)

Building on this moral foundation, ecosystem considerations are woven into every project stage, transforming compliance into hands-on restoration. As specialists explain,

> *As ecologists, we are expected to offer professional guidance, ensuring clients meet environmental regulations and advising on Biodiversity Net Gain, now a compulsory target. Our recommendations often lead to direct engagement in implementing these enhancements, benefiting both the client and our own businesses* (NPF – 10)

When capital is explicitly channelled into habitat recovery, solar farms become long-term restoration projects that embed ecological integrity across their lifecycle:

> *The lifecycle of solar farms, from development to operation, offers opportunities for long-term ecological benefits through sustainable practices and habitat restoration* (NPF – 11)

Building on this practical investment, the interpretation of the Biodiversity Net Gain (BNG) has shifted from a regulatory hurdle to a strategic opportunity to strengthen ecosystem integrity and enhance natural capital:

> *There is a legal obligation for major projects to achieve significant biodiversity net gain, with solar projects often aiming for 50% – 70%, exceeding the mandated 10%. Some clients are considering selling surplus BNG as credits (NPF – 10).*

Finally, regenerative practice is revealed through participatory management:

> *Our clients encourage us to monitor the sites and suggest improvements. They want us to look for opportunities to enhance biodiversity and report any failures, such as plants that haven't survived…this proactive approach aligns with our training and professional responsibilities* (NPF – 10)

By embedding continuous monitoring and stakeholder collaboration into project workflows, organisations treat both successes and setbacks as catalysts for ongoing ecological learning – and in doing so, avoid the degradation from traditional land uses.

Biodiversity Resilience for Ecosystem Services Functions and Services. At the heart of ecosystem-based orientation lies the goal of biodiversity resilience, which aligns land-use decisions with ecological processes. In solar farms, such resilience is built through four complementary strategies, moving from ecosystem structure to ecosystem function. At the structural level of ecosystems design, prioritising the creation and safeguarding of core habitats is key to maintain viable wildlife populations and connectivity. As noted,

> *Creating or protecting habitats—through measures like installing nesting boxes, retaining hedgerows, and establishing wildflower meadows—ensures viable populations and supports essential ecosystem processes* (NPF–3)

By treating each site as part of a larger ecological network, managers preserve the population connectivity essential for genetic diversity and long-term species survival.

To achieve true resilience, it is essential to transform management from a one-off intervention into an adaptive partnership with nature. Regular ecological surveys enable teams to detect stressors early and refine management approaches. As noted by a participant:

> *Commitment to long-term ecological monitoring – tracking species usage, vegetation changes, and habitat quality enables teams to learn from data, adjust management practices, and uphold ecological value over time* (NPF–4)

Notably, healthy and biodiverse systems underpin key services – pollination, soil stability, and water regulation – that support both agriculture and landscape resilience. As one specialist highlighted:

> *Enhancing ecosystem services, such as supporting pollinator communities, stabilising soils against erosion, and improving water infiltration, highlights the indirect yet indispensable benefits of ecological restoration* (NPF–5)

Functioning ecosystems serve dual roles drawing down carbon and offering migration corridors for species adapting to climate change. As one interviewee noted:

> *Well-connected habitats serve as carbon sinks and stepping-stones, providing refuge and migration pathways that enhance species resilience in shifting climates* (NPF–6)

By interweaving hedgerows, and grasslands, solar farms not only store carbon but also facilitate species movements – delivering resilience at multiple scales.

INSERT FIGURE 1 HERE

4.2. Inter-firm Activity and Influence in UK Solar Farm Sector

Our findings identify five inter-firm activities that influence how biodiversity value is created and sustained in the UK solar farm sector (see Table 2): *investor relations management (IRM), strategic and operational management (SOM), biodiversity and nature-positive initiatives (BNI), collaboration and community impact (CCI) and policy engagement and compliance (PEC)*. These activities are not isolated; they interact, shaping how firms interpret, manage and leverage biodiversity within a complex and evolving environment.

4.2.1 IRM and SOM Relationships

Investor’s demands for credible ESG and biodiversity outcomes shape how firms structure their strategic and operational responses. For example,

> *When investors are interested in ESG-related, nature-positive activities but are unsure of what those activities entail, it’s the role of the service provider to guide them. The investment manager needs to identify and create awareness of these unmet needs, manage the process to address them, and then we can step in to deliver the solutions (NPF – 1)*

In response, firms’ strategic management practices help translate broad investor expectations into actionable biodiversity initiatives, creating strategic and operational routines that reinforce transparency and accountability. As noted,

> *…they [investors] enjoy visiting solar parks… Being on-site allows them to directly witness the impact of these assets on the environment… This experience tends to leave a strong impression on investors, making them more likely to talk about it and invest (NPF–5)*

This interplay suggests that investor expectations are operationalised through strategic planning, ecological enhancement activities, and transparent reporting mechanisms. In turn, strong delivery on biodiversity-related objectives reinforces investor trust and supports competitive positioning.

4.2.2 SOM and BNI Relationships

Strategic management decisions play a central role in shaping the implementation of nature-positive measures through ecological management tools, such as Landscape and Ecological Management Plans (LEPMs) and Ecological Management Systems (EMS):

> *Our primary impact on biodiversity is through tailored management actions… promoting better management practices… (NPF–7)*
>
> *We base our work on the LEMP… including where specific plants should be placed and where wildflower meadows should be established...(NPF–10)*

Once implemented, the effect of these biodiversity measures is assessed through ecological surveys, ecosystem service indicators, or sustainability reports. This monitoring provides feedback on what is effective, what needs improvement, and where ecological and strategic gaps may exist. For instance,

> *The detailed plans in the LEMP allow for consistent monitoring… ensuring that ecological goals are met (NPF–10)*

These insights allow firms to adjust their targets, revise biodiversity priorities or reallocate resources to improve outcomes. As indicated,

> *We are beginning to investigate the broader impacts of our management actions… enhance our contribution to ecosystem services beyond biodiversity (NPF–7)*

This iterative process creates a dynamic feedback loop between strategic planning and ecological performance, which allows firms to integrate learning into continuous environmental improvement.

4.2.3 BNI and CCI Relationships

Implementing biodiversity initiatives often requires technical knowledge and local insights, which firms acquire through partnerships with ecological experts, cross-sector actors, and local communities. These collaborations help ensure that biodiversity actions are scientifically sound and socially relevant. As explained:

> *Collaborative efforts involving ecologists, technical analysts, and local planning authorities are crucial for identifying the variety of habitats and species on the sites and implementing these opportunities (NPF–2)*

Additionally, collaborating across industries helps develop unified standards, share best practices and foster mutual accountability. Doing so helps firms effectively align biodiversity initiatives with broader sustainability objectives. For example,

> *…collaborating with other sectors to share best practices and develop unified standards can enhance the overall effectiveness of sustainability initiatives (NPF–9)*

Furthermore, engaging with academic institutions creates opportunities for environmental education and stakeholder learning. For instance, sharing knowledge with farmers improves understanding of biodiversity management and supports compliance with site-specific ecological goals (NPF – 7).

Community engagement is equally important in delivering biodiversity outcomes. Firms increasingly involve local residents and experts to ensure that appropriate actions are taken and sustained over time (NPF – 1). This is reinforced through educational outreach, where firms partner with local schools and environmental groups to promote awareness and co-create environmental value. As shared,

> *We support local schools and the community by conducting training sessions and educational activities… collaborate with local green groups to run environmental sessions (NPF–7).*

Effective communication is essential in this process. To engage with diverse stakeholders, firms aim to simplify complex ecological information and foster an ongoing dialogue. As explained:

> *Our approach to communication is to simplify things… We maintain ongoing discussions about the value of nature, opportunities for biodiversity net gain, and the societal benefits of these efforts (NPF–6).*

Together, these practices underscore that successful biodiversity strategies are not developed in isolation – they rely on inclusive, transparent and collaborative engagement with both experts and communities.

4.2.4 CCI and PEC Relationships

Cross-sectoral collaboration plays a critical role in shaping how firms engage with and respond to policy and compliance demands. Industry-wide partnerships offer a mechanism for firms to influence and co-develop biodiversity standards. For instance,

> *We work with industry bodies like Solar Energy UK to provide guidance on biodiversity management for the whole industry… (NPF–6)*

These collaborative efforts not only help shape emerging policy frameworks but also ensure that compliance measures are more grounded in practice and feasible to implement. By participating in these forums, firms contribute to the codification of best practices and build credibility with regulators and peers alike.

At the same time, policy frameworks and compliance mechanisms actively encourage collaboration, especially with local communities. Initiatives such as BNG and the trading of biodiversity units offer financial and reputational incentives for firms to engage in community-facing biodiversity actions. As participant NPF–1 noted,

> …*We provide [communities] with quarterly updates on progress and conduct annual reporting to track and review our efforts (NPF – 1)*

This reflects how regulatory expectations around transparency and reporting help institutionalise ongoing community engagement. Additionally, firms increasingly formalise roles and responsibilities to ensure that ESG targets are met, and that community and regulatory engagement are embedded into day-to-day operations. As stated:

> *We maintain a clear separation between the board and the executive committee to ensure effective management and operational efficiency (NPF – 11).*

Such governance structures foster accountability and support long-term integration of compliance obligations with stakeholder engagement efforts.

4.2.5 IRM and PEC Relationships

Investor relations management is increasingly shaped by compliance narratives, where meeting or exceeding regulatory benchmarks (e.g., BNG, SFDR) becomes a competitive asset. Firms that demonstrate compliance with biodiversity frameworks, such as through the trading of surplus biodiversity unites, are seen as environmental leaders. As noted,

> *Trading surplus biodiversity [units could] offer a new revenue stream…[while] demonstrating leadership in environmental compliance (NPF–8)*

Investors are also using regulatory frameworks such as the Sustainable Finance Disclosure Regulation (SFDR) as a proxy for credibility. As highlighted,

> *Under the SFDR regulation, funds are required to classify themselves into different ESG performance categorises… the EU has intervened and required these funds to downgrade their ratings because they are overestimating their own ESG credentials (NPF – 5)*

This illustrates how investor relations are shaped by regulatory integrity – overstating ESG performance can lead to reputational damage and lost investment opportunities.

Firms are also leveraging policy-aligned reporting to strengthen their investor communications. For instance, one firm's ESG report not only demonstrated environmental impact but also directly linked this impact to investor returns:

> *Investors have enjoyed an average annual return of 10 –11 % over the past ten years (NPF – 4)*

Such disclosures serve to bolster investment narratives that connect environmental stewardship directly to financial success. In this context, compliance becomes more than a legal obligation – it acts as a strategic signal to investors about a firm's long-term environmental and reputational commitment. This dynamic reinforces a compliance-as-strategy logic: being ahead on regulation boosts investor confidence, and meeting policy benchmarks unlocks capital and reputation benefits.

4.3. Synthesising Strategic Value Orientations with Challenges, Opportunities and Tensions in Inter-firm Activities

Our findings show that most biodiversity-related activities reflect integrative value, with instrumental value evident across three thematic areas and ecosystem-based value emerging in two (See Table 3). Each value orientation shapes distinct patterns of challenge, opportunity and tensions (See Table 4). Notably, tensions are not signs of failure; rather, they are generative by highlighting misalignments in practices, timeframe, metrics and expectations that must be negotiated for authentic value co-creation.

4.3.1 Instrumental Orientation: Biodiversity as a Strategic Tool

Firms operating with an instrumental logic tend to view biodiversity and sustainability initiatives as a strategic tool to enhance reputation, attract investment, meet compliance and improve operational efficiency. This approach was prevalent among firms seeking to align biodiversity efforts with ESG mandates and investor expectations.

Challenges. Firms adopting an instrumental orientation face several significant challenges. These include a lack of biodiversity-specific expertise and ecological awareness, particularly among financial actors and generalist fund managers, which constrains strategic integration. For example, one participant highlighted:

> *Lack of knowledge [about biodiversity and its integration] can be a significant barrier for us… a lot of our peers have no understanding of these concepts (NPF–9)*

Furthermore, the absence of standardised biodiversity metrics and fragmented reporting practices create inconsistencies that reduce transparency and comparability across projects.

> *Everyone does it differently… every funder will pick their own metrics, which makes it very difficult for us to compare (NPF–9)*

The limited availability of investable nature-positive assets also presents a structural barrier to market participation.

There is such a scarcity that we might be choosing between two funds, whereas, in other areas, we could be choosing between 2000 funds (NPF–9)

Smaller firms are further constrained by resource limitations, affecting their capacity to design, implement, and monitor biodiversity initiatives at scale.

Time constraints and limited resources hinder our ability to focus on it as much as we should (NPF–7)

Opportunities. Despite these constraints, the instrumental orientation enables firms to leverage biodiversity initiatives for competitive advantage. Enhancing ESG credentials strengthens tender applications and improves investor appeal, particularly in markets increasingly shaped by sustainability performance.

Clients are increasingly highlighting their contributions to biodiversity…to help improve their ESG profile and attract investment (NPF– 5)

Firms are also integrating biodiversity into financial products, which open access to new capital flows.

Investors are interested in whether there are mechanisms like biodiversity credit that can provide tangible value, like how carbon credits work (NPF–4)

On the ground, sustainable land management practices provide cost-saving opportunities while fulfilling regulatory requirements (NPF–7). Moreover, the potential for monetising ecosystem services – through mechanisms like Payments for Ecosystem Services (PES) or discounted cash flow (DCF) modelling – highlights biodiversity's financial utility (NPF–4, 7).

Tensions. Instrumental actors often experience a persistent pressure to deliver short-term financial returns, which can conflict with the longer time horizons required for meaningful biodiversity outcomes. As noted,

There is an inherent tension between achieving financial returns and maintaining environmental commitments… (NPF–11)

Additionally, the reliance on simplified or symbolic metrics risks overlooking ecological nuance. The pursuit of biodiversity as a performance indicator may reduce it to a compliance exercise, rather than fostering genuine stewardship. As a result, firms must navigate the trade-off between ecological credibility and market performance (NPF–10).

4.3.2. Integrative Orientation: Embedding Biodiversity within Stakeholder Engagement

The integrative orientation reflects a shift towards embedding biodiversity into the governance structures, operational planning and inter-organisational practices of firms. Firms adopting the integrative orientation tend to align biodiversity with their organisational values, stakeholder expectations and adaptive land management. This approach is particularly evident in firms that view biodiversity as integral to long-term sustainability and social legitimacy.

Challenges. Firms pursuing an integrative approach often experience persistent operational inconsistencies in the application of biodiversity practices across solar projects due to variations in site conditions, partner capabilities and implementation oversight. As noted,

> *The solar park industry lacks a consistent approach to implementing nature positive practices across all projects (NPF–11)*

Furthermore, fragmented communication between stakeholders (e.g., developers, fund managers, contractors, conservation groups) creates coordination gaps that hinder effective planning and monitoring (NPF–9). Thirdly, landowner capacity and training remain limited; many farmers and leaseholders lack the ecological literacy to actively support biodiversity goals (NPF–7). Finally, gaps in adaptive management and feedback loops mean that biodiversity plans are not always updated in response to site data or changing ecological conditions, which risk reducing their effectiveness over time (NPF–6).

Opportunities. However, the integrative orientation generates substantial opportunities for innovation and learning. As firms noted,

> *Working with various stakeholders, including developers, local authorities, and conservation organisations, ensures that diverse perspectives are considered in ecological planning (NPF–7)*

and

> *We're working with clients to understand how biodiversity fits into their ESG strategy—it's not a one-size-fits-all. The key is to align impact with purpose (NPF–5)*

The co-creation of ecological value through stakeholder-driven innovation helps to anchor biodiversity efforts in context-specific needs. In addition, cross-sector collaboration fosters the enhancement of inter-organisational alignment, with firms sharing best practices, frameworks and tools to advance common biodiversity goals.

Environmental education and community outreach further strengthen stakeholder engagement and build ecological capacity beyond the project site (NPF– 7,9)

Tensions. Yet, a key tension arises from traditional land use practices that conflict with biodiversity requirements, particularly when farmers or landowners often continue to use the land as if it were still solely theirs (NPF–7). Additionally, commercial confidentiality can limit the transparency needed to share biodiversity achievements publicly or build shared accountability, particularly in investment-facing communications. As noted,

> *Discussing the firm's nature-positive efforts is complicated by the need to maintain client confidentiality, limiting the ability to openly share and promote these initiatives (NPF–11)*

Lastly, firms must balance involving stakeholders in decision-making with maintaining operational control to ensure consistent ecological outcomes. Managing this tension is resource intensive, as it requires robust governance mechanisms, transparent engagement strategies, and long-term commitments to adaptive planning (NPF–7)

4.3.3. Ecosystem-Based Orientation: Recognising Nature's Intrinsic Value

The ecosystem-based orientation reflects a deeper ecological and ethical commitment to biodiversity, where nature is recognised not merely for its instrumental utility but for its intrinsic value and functional role in sustaining resilient ecosystems. Within this priority, biodiversity is viewed as a regenerative asset, deeply embedded in long-term land use, climate adaptation and ecological restoration strategies.

Challenges. Organisations adapting an ecosystem-based orientation encounter market challenges. As noted,

> *A significant challenge is building trust in the viability and stability of new markets (NPF–4)*

Moreover, small businesses often find their ambitions constrained by the scale at which they operate, as

> *The size and limited resources make it challenging to independently create and manage large initiatives (NPF–9)*

In addition, the environmental and social impacts of supply chains—including the sourcing of raw materials and the carbon footprint of panel manufacturing —

undermine the ecological credibility of solar developments (NPF–11). Furthermore, biodiversity is often treated as an offset—a compensatory measure to balance environmental harm elsewhere—rather than as an embedded and ongoing priority within each project's lifecycle (NPF–7).

Opportunities. Despite this, the ecosystem-based orientation unlocks a range of forward-looking opportunities, such as system-wide innovation and strategic framing. Our findings show that many firms are beginning to frame Biodiversity Net Gain (BNG) not just as a compliance requirement but as a strategic opportunity to contribute to ecological restoration and natural capital (NPF–4, 10). The growth of biodiversity-focused markets, such as eco-tourism and regenerative farmland investment, reflects an emerging economic space where ecosystem health is both a goal and a source of value. As noted,

> *The biodiversity world is booming at the moment, and there is a huge demand for the kind of biodiversity enhancement work we specialise in (NPF–6)*

Organisations are also pioneering new assessment frameworks, including ecosystem service metrics and solar-specific BNG tools, that support more accurate and place-based ecological evaluations (NPF–7). Importantly, cross-sector learning through focus groups, academic partnerships, and industry forums has facilitated the exchange of practical insights, further strengthening systemic understanding and innovation (NPF–9).

Tensions. However, the ambition of this orientation introduces several tensions. One key issue is the overreliance on biodiversity offsetting, which may divert attention from site-level ecological enhancement and create a false sense of balance (NPF–7). Another tension lies in the complexity of formal ecosystem accounting, which often clashes with the desire for simplified, quantifiable ESG indicators—potentially undermining the depth and nuance of biodiversity reporting (NPF–10). As noted,

> *…The need for a nuanced understanding of environmental impacts contrasts with the desire for simplified, easily understandable metrics that may overlook important details (NPF–10)*

Finally, the long timeframes and spatial scales required for meaningful ecosystem stewardship frequently conflict with the fast-paced timelines of commercial development cycles (NPF–7).

5. DISCUSSION AND CONCLUSION

The Natural Resource-Based View (NRBV) has been foundational in explaining how firm derive competitive advantage from environmental capabilities (Hart, 1995). However, the framework largely assumes that the ‘natural environment’ is a generalised external domain rather than a differentiated ecological system with spatial, regulatory and multi-actor interdependencies (Hart & Dowell, 2011). Our study extends this theoretical foundation by demonstrating that biodiversity is not merely one natural resource among many, but a structuring social-ecological mechanism that shapes strategic action, capability development, and inter-organisational coordination in ecologically embedded sectors. Decisions regarding land and asset management, habitat design and ecological monitoring generate ecological feedback effect that influences planning permissions, community relations, investor expectations and operational risk – revealing that strategic value creation in biodiversity-dependent sectors is inherently relational and systemic.

5.1 Implications for Theory

5.1.1 Reframing Biodiversity as a Structuring Social-Ecological Mechanism

Our study advances the NRBV by reconceptualising biodiversity as a structuring social-ecological mechanism that conditions how environmental capabilities emerge, interact and generate value. NRBV scholarship has traditionally conceptualised natural resources as external inputs to be conserved, substituted or managed for cost efficiency and risk mitigation (Hart, 1995; Hart & Dowell, 2011). Our findings show that biodiversity shapes the interdependencies, constraints and opportunities firm encounter in ecologically embedded infrastructures. This aligns with research on biodiversity-ecosystem functioning (Tilman, 1999; Duffy et al., 2017) and social-ecological systems, which emphasis feedback loops and co-evolution between ecological and institutional processes (Ostrom, 2009; McGinnis & Ostrom, 2014). Decision on land management, habitat design, and ecological evaluation and monitoring generate feedback effects that influence planning approval, investor expectations and social licence (Whiteman, Walker & Perego, 2013). This relational influence challenges the NRBV’s firm-centric assumption and suggests that environmental capabilities must be understood within coupled social-ecological systems, not solely within organisational boundaries (Winn & Pogutz, 2013).

5.1.2 Empirically Demonstrating Biodiversity-Oriented Strategic Orientation

Our second contribution is empirical. We identify three biodiversity-oriented strategic orientations – instrumental, integrative and ecosystem-based (see Figure 3) – that illustrate how firms enact different logics when responding to biodiversity as a structuring mechanism. These orientations do not constitute NRBV constructs; rather, they provide empirical evidence of the diverse logics through which firms navigate biodiversity pressures. The instrumental orientation aligns with pollution-prevention logics (Hart, 1995; Christmann, 2000), treating biodiversity as a means to reduce risk, meet regulatory thresholds and enhance ESG performance. The integrative orientation embeds biodiversity in stakeholder relationships and value co-creation, resonating with relational perspectives on environmental governance and legitimacy (Angus-Leppan, Benn & Young, 2010; Montiel, Gallo & Antolin-Lopez, 2020). The ecosystem-based orientation reflects a regenerative logic consistent with sustainable development and nature positive strategy (Bocken & Geradts, 2020; De Angelis, 2022), where firms invest in long-term ecological stewardship and landscape-scale restoration. These orientations show that biodiversity value creation is multi-logic and multi-actor, not exclusively efficiency driven. They also extend environmental strategy scholarship that distinguishes between reactive, proactive and paradox-navigating responses (Sharma & Vredenburg, 1998; Hahn et al., 2015). They clarify the conditions under which biodiversity becomes a source of competitive advantage – through legitimacy building, relational governance, and ecosystem-level restoration (Ahenkora, 2025; Haile & Min, 2023).

INSERT FIGURE 3 HERE

5.1.3 Extending NRBV Boundary Conditions to Ecologically Embedded Sectors

Our third contribution extends the empirical and conceptual boundary conditions of the NRBV by showing that environmental capabilities in ecologically embedded sectors are distributed, co-produced and system-level, rather than solely firm-level capacities. The solar farm sector is characterised by strong ecological embeddedness, mandatory biodiversity regulations (e.g., Biodiversity Net Gain), complex land-use negotiations and multi-actor habitat management responsibilities. In such setting, capabilities emerge not from internal optimisation but from inter-organisational coordination, shared ecological sensing (Schmeller et al., 2017), cross-sector partnerships (Folke et al., 2010) and adaptive governance of social-ecological systems (Carvalho et al., 2024). This implies that competitive advantage therefore arises not only from firm-level capabilities but from ecosystem-level and networked capabilities that operate across social-ecological systems – an area incompletely addressed in existing NRBV theory.

5.2 Implications for Practice

Our findings offer several managerial implications for firms navigating the complex interplay between biodiversity and net zero transitions, especially in the renewable energy industry. Firstly, the instrumental orientation, which frames biodiversity as a lever for reputation, investment, compliance, and operational efficiency, aligns with current trends in ESG and nature-related risk disclosure, yet risks reinforcing narrow and reactive approaches. Managers must move beyond biodiversity as a risk mitigation checkbox to recognise it as a strategic asset. As shown in the literature (Gasparatos et al., 2017; Korn et al., 2019), biodiversity loss and climate change are interlinked crises; therefore, failing to embed biodiversity into project design could result in reputational damage, investor disengagement, or increased regulatory scrutiny. Pollution prevention strategies (e.g., land-use efficiency, reduced chemical pollution, and habitat-compatible sitting) are not only ecologically prudent but economically advantageous when linked to emerging biodiversity credit markets and corporate sustainability metrics; one important aspect often overlooked is their connection to biodiversity dependencies, which can enhance business resilience by clarifying both risks and opportunities within strategic management

Secondly, an integrative orientation underscores the managerial importance of embedding biodiversity considerations into governance structures, stakeholder relations, and adaptive management. Renewable energy developments frequently generate ecological-social tensions or trade-offs (Froidevaux et al., 2024; Rehbein et al., 2020). Managers should therefore invest in participatory planning processes, community co-design and long-term ecological monitoring to align biodiversity outcomes with project lifecycles. Collaborative approaches such as agrivoltaics, community-led monitoring, and the use of degraded lands for development (Santangeli et al., 2016; Usiagu et al., 2024) help reconcile stakeholder expectations and ecological goals. Furthermore, while the inherent variability of natural systems – along with external factors beyond the control of solar operators – makes it challenging to measure success accurately or attribute specific ecological outcomes to individual interventions, long-term monitoring supported by robust feedback loops allows managers to respond dynamically to ecosystem change. This approach helps align biodiversity stewardship with the adaptive requirements of renewable project lifecycles.

Thirdly, the ecosystem-based orientation, which values nature for its intrinsic worth and functional integrity, pushes managerial practice toward regenerative business models and deeper systemic accountability. In contrast to passive restoration, managers must view renewable energy infrastructure as platforms for active ecosystem enhancement. This includes designing for species movement corridors, enhancing pollinator habitats, and leveraging conservation finance to fund restoration beyond compliance. As the literature highlights (Armstrong et al., 2016; Gómez-Catasús et al., 2024), ecological disruptions can occur even with green technologies; thus, biodiversity must be treated not as a secondary impact but a core organising principle of energy transition strategies. By recognising different value orientations and associated practices, firms can develop ecosystem-level capabilities and collaborate across value chains to shift their orientation and create regenerative values for sustained competitive advantage.

5.4 Implication for Policy

Our findings reveal a pressing need for more integrated policy frameworks that reconcile the interconnected goals of biodiversity conservation and renewable energy expansion – two pillars of climate-resilient development. As the renewable energy sector accelerates to meet net-zero targets, policy interventions must evolve to address the ecological externalities and biodiversity trade-offs inherent in large-scale infrastructure deployment (Lafitte et al., 2023; Rehbein et al., 2020).

Firstly, policy instruments must go beyond carbon-centric metrics and explicitly embed biodiversity considerations into energy governance. Current regulatory frameworks often mandate environmental impact assessments but frequently lack standardised, enforceable biodiversity criteria. Policies should adopt biodiversity-specific performance standards to guide project approval, monitoring, and adaptive management. This would help prevent the treatment of biodiversity as a secondary or offsetable issue and incentivise nature-positive energy transitions (Kaimba et al., 2019; Schmeller et al., 2017).

Secondly, governments should promote land-use planning policies that integrate spatial biodiversity data to optimise renewable energy siting. Strategic siting on degraded, low-ecological-value lands (e.g., brownfields, or post-industrial sites) can significantly reduce habitat loss and species displacement (Santangeli et al., 2016). Regional planning frameworks that account for ecosystem connectivity and species migration patterns would enhance the ecological compatibility of solar and wind installations — addressing growing concerns over their footprint (Froidevaux et al., 2024; Gómez-Catasús et al., 2024).

Thirdly, biodiversity-focused fiscal and financial policy tools must be scaled and diversified. Blended finance mechanisms, biodiversity-linked bonds, and tax incentives for habitat restoration can help private capital toward ecological enhancements on renewable sites. Policymakers can support this by establishing transparent biodiversity credit markets aligned with verified ecological matrices. Furthermore, integrating biodiversity risks into disclosure regulations (e.g., TNFD) can improve accountability and shift market norms toward valuing nature as a strategic asset.

Finally, policies should incentivise multi-stakeholder governance and adaptive management. Our findings highlight that integrative value creation such as stakeholder co-design and operational feedback loops is essential for effective biodiversity outcomes. National and regional policies can support this through co-production frameworks, participatory planning requirements, and the inclusion of biodiversity indicators in community benefit agreements. In tandem, capacity-building programmes for landowners, local authorities, and renewable developers can help bridge knowledge gaps and strengthen collaborative ecosystem stewardship.

5.5 Limitations and Future Research

This study provides valuable insights into how biodiversity, as a public good, transforms into a strategic asset of firms that shape their competitive advantage, but it is not without limitations. These limitations highlight opportunities for future research to build upon and extend our findings. Firstly, the study is situated within England, focusing exclusively on firms operating in the solar industry. While this offers a detailed understanding of biodiversity initiatives in this specific setting, the generalisation of our findings to other countries or industries remains uncertain. Future research could expand upon this work by examining biodiversity strategies across different national and industrial contexts such as agriculture, manufacturing, or other energy sectors – to identify broader patterns, sectoral nuances, and cross-contextual insights. Secondly, the study primarily focuses on the downstream value activities in the value chain. A more comprehensive view would include upstream supply chains, where biodiversity risks related to sourcing, extraction and production often arise. Future studies could explore how firms manage biodiversity impacts across the entire value chain, especially in high-impact industries. Thirdly, our reliance on qualitative data introduces potential biases inherent to self-reported information. Although we sought to mitigate this by incorporating multiple data sources to validate and triangulate the findings, qualitative methods may lack the objectivity and replicability of quantitative approaches. Future studies could address this limitation by employing longitudinal techniques to enhance reliability and provide more generalisable insights. For example, tracking the long-term impacts of biodiversity initiatives and multi-stakeholder partnerships would offer a dynamic perspective on how tensions and strategies evolve over time. Finally, our study is anchored in a single theoretical framework, which, while offering depth, also limits the scope of interpretation. Future research could build on this work by applying alternative organisational or economic theories to offer broader perspectives biodiversity-business relationships and uncover additional insights.

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Table 1: Sample cases

Case No.	Industry	Industry Position (Quotes Summary)	Firm Size
1	The Asset Management	‘Managing and optimising solar energy assets across various stages of their lifecycle: development, construction, and operational management of solar plants’ (NPF – 1)	Medium
2	The Industry Association	‘Working closely with a full range of businesses in the solar and storage value chain (e.g., installers, distributors, manufacturers, law firms, ecologists) daily’ (NPF – 3)	Small
3	Investment Banking	‘Specialising in the energy sector, encompassing renewable energy, energy transition and the broader energy and infrastructure landscape’ (NPF – 4)	Large
4	The Environmental Consulting	‘Concentrating on improving the biodiversity value of solar…’ (NPF – 6)	Small
5	The Environmental Consulting	‘Evaluating the ecological constraints of sites presented by developers, providing an initial assessment of biodiversity and ecological constraints’ (NPF – 7)	Small
6	The Legal Service	‘Specialising in large-scale solar farms, typically ranging from 20 megawatts to 750 megawatts, often with associated battery storage’ (NPF – 8)	Large
7	The Investment Management	‘Focusing on managing £1.5 billion in assets with an emphasis on sustainable and impact investing’ (NPF – 9)	Large
8	The Environmental Consulting	‘Managing both the maintenance and ecological aspects of solar farm sites, including tasks like general upkeep, planting, fence repairs, and conducting ecological surveys to ensure environmental sustainability’ (NPF – 10)	Medium
9	The Legal Service	‘Pioneering role in the industry, contributing significantly to establishing standard legal language and document templates, which are now widely used in the industry’ (NPF – 11)	Large

Table 2: Biodiversity-related activity themes

Aggregated theoretical dimensions	**Second-order value themes**	**First-order activity codes**	**Illustrative quote/synthesised insight examples**
Investor relations management (IRM)	Addressing investors' implicit needs	• Identifying unmet investor needs • Creating investor awareness	*'The investment manager needs to identify and create awareness of these unmet needs...' (NPF – 1)* *There's often a gap between what investors think they're asking for and what's really needed on the ground. Our role is to translate those broad ESG goals into something concrete and context-specific' (NPF–3)* *"...when investors are interested in ESG-related, nature-positive activities but are unsure of what those activities entail..." (NPF– 1)* *'Investors are increasingly interested in biodiversity, but many still lack the knowledge or frameworks to properly evaluate it. We try to bridge that gap with clear metrics and storytelling' (NPF–6)*

	Structuring strategic ESG responses	• Managing expectations and ESG process • Translating ESG interests into action	*'To manage investor expectations, we regularly update our biodiversity progress reports and link them to ESG benchmarks they're familiar with' (NPF–5)* *'It's one thing to say your nature-positive; it's another to embed that into the entire land management plan and back it with scientific evidence' (NPF – 7)* *'...manage the process to address them... translate investor needs into actionable strategies…' (NPF – 1)*
	Delivering biodiversity-aligned outcomes	• Service provider guidance and engagement • Coordinating delivery of biodiversity solutions	*'When clients or investors don't understand BNG, we don't just explain it—we offer to walk them through example projects, what worked, and what didn't' (NPF–2)* *'We work closely with ecologists, landscape architects, and planning consultants to ensure our biodiversity measures are not only effective but feasible to deliver' (NPF – 10)* *'It's the role of the service provider to guide them…and then we can step in to deliver the solutions' (NPF – 1)*

	Attracting responsible investments	• Aligning with ethical investor priorities • Demonstrating nature-positive outcomes	*‘Such organisations not only align with investors’ ethical and sustainability goals but also instil greater confidence by showcasing their commitment to long-term, responsible stewardship’ (NPF – 10)* *‘Potential investors are more likely to support projects that show significant improvements in habitats and the local environment’ (NPF – 10)*
	Simplifying investment structures	• Reducing complexity for investor accessibility • Improving capital raising via structural clarity • Linking ESG success with financial returns	*‘We simplify the process of listing on the London Stock Exchange to facilitate capital raising...started with a £260 million IPO and has grown to nearly £4 billion today… Recently, they published their ESG report…Investors have enjoyed an average annual return of 10–11% over the past ten years’ (NPF – 4)*
Strategic and operational management (SOM)	Building operational transparency with investors	• Facilitating on-site investor learning	*‘They [investors] enjoy visiting solar parks to see how everything operates, speaking with the staff who manage the day-to-day activities, and observing how the performance of the assets is optimised. Being on-site allows them to directly witness the impact of these assets on the environment’ (NPF – 5)*
	Market differentiation	• Leveraging ESG commitment for brand positioning	*‘ESG commitment, including nature positive aspects, is a differentiator in the banking industry and this can significantly enhance a bank’s reputation and market position’ (NPF – 5)*

	Risk management through transparency	• Addressing greenwashing concerns • Avoiding tokenistic ESG implementation	*‘Since not all investors are specialists and many struggle to keep [up] with changes, they often worry about greenwashing and their ability to accurately interpret the data. For example, a company might advertise its nature positive initiatives, but there could be other negative environmental impacts that investors might overlook’ (NPF – 5)* *‘Since not all investors are specialists and many struggle to keep [up] with changes, they often worry about greenwashing and their ability to accurately interpret the data. For example, a company might advertise its nature positive initiatives, but there could be other negative environmental impacts that investors might overlook’ (NPF – 5)*

	Embedding authentic sustainability in business models	• Integrating sustainability into core operations • Enhancing internal understanding of ESG • Aligning ESG with strategic oversight • Building ecosystem-wide capacity for identifying legitimate sustainability-oriented investments	*‘We maintain a clear separation between the board and the executive committee to ensure effective management and operational efficiency; implementing comprehensive governance frameworks including oversight by non-executive directors and chairs maintains accountability and transparency’ (NPF–11)* *‘We offer specialised legal and regulatory advice in negotiating contracts and arranging debt financing to ensure financial stability and compliance, which are essential for project success…’ (NPF – 11)* *‘Governance within firms is strengthened by a clear delineation of roles and responsibilities, particularly between the board and the executive committee… Such frameworks foster transparency and accountability, which are critical for sustaining investor trust and operational integrity’ (NPF– 11)*
	Efficiency and cost-effectiveness	• Optimising field equipment; advising on low-cost land use	*‘Efficient use of field equipment and expertise allows us to perform high-quality surveys and assessments, maximising the productivity of our resources and ensuring reliable results’ (NPF – 7)*
	Customer satisfaction	• Maintaining diverse client offerings and long-term services • Supporting clients with ecological regulation and development processes	*‘We maintain a diverse range of projects to ensure that we meet various client needs and preferences’ (NPF – 7)* *‘Assisting clients through the planning process, ensuring ecological considerations are integrated into development proposals and addressing regulatory requirements’ (NPF – 7)*

		• Proactively supporting clients in achieving sustainability outcomes	*‘The main way we make a positive impact is by providing services that help our clients achieve their ESG and biodiversity objectives… If we didn't actively push to get things done properly, they [our clients] might not achieve their objectives effectively. Because we care, we put in the extra effort. This aspect isn't a profitable part of our business, but it's something we are committed to doing regardless’ (NPF – 1)*

Biodiversity and nature-positive initiatives (BNI)	Ecological assessment and management planning	• Conducting baseline ecological assessments • Implementing Landscape and Ecological Management Plans (LEMPs) • Ensuring long-term ecological monitoring and updates • Applying tools for ecosystem service evaluation • Adaptive management for resilience	*'We base our work on the LEMP… including where specific plants should be placed and where wildflower meadows should be established… it also specifies the types of chemicals that can be used and whether spot spraying or boom spraying is appropriate' (NPF –10)* *'The detailed plans in the LEMP allow for consistent monitoring and maintenance, ensuring that ecological goals are met' (NPF– 10)* *The detailed plans in the LEMP allow for consistent monitoring and maintenance, ensuring that ecological goals are met…' (NPF – 10)* *'The detailed plans in the LEMP allow for consistent monitoring and maintenance, ensuring that ecological goals are met' (NPF – 7)*

	Ecological reporting and outcome communication	• Tailoring site management to biodiversity insights • Promoting ecosystem services through better practices • Using ecological data to support decision-making • Balancing financial drivers with ecological co-benefits	*'Our primary impact on biodiversity is through tailored management actions… balancing sensible site maintenance and habitat restoration… promoting better management practices indirectly support these ecosystem services' (NPF–7)* *'Promoting better management practices indirectly support these ecosystem services' (NPF–7)* *'The information gathered from ecological surveys informs development plans and provides insights into how projects can impact local ecosystems, shaping tailored management actions' (NPF–7)* *'The financing behind solar projects is a key driver, although it often remains separate from direct ecological considerations. The push for solar arrays aligns with broader ecological goals' (NPF – 7)*

	Integrated land use and nature-positive design	• Designing dual-use solar farms • Maintaining land viability for future ecological use • Creating synergies between energy and ecosystem services	*'Utilising land for solar farms in a way that integrates ecological considerations ensures the land remains viable for future use and benefits the environment' (NPF–11)* *'...ensures the land remains viable for future use and benefits the environment (NPF–11)* *'Integrating ecological measures into the design and management of solar farms enables management to see tangible outcomes that not only enhance biodiversity but also contribute to ecosystem services beyond just energy generation, such as carbon sequestration and water management' (NPF–7)*

Collaboration and community impact (CCI)	Inter-firm collaboration with the industry	• Collaborating with ecologists and planning authorities • Cooperating with competitors for shared environmental goals • Accelerating sector-wide sustainability outcomes	*'Collaborative efforts involving ecologists, technical analysts, and local planning authorities are crucial for identifying the variety of habitats and species on the sites and implementing these opportunities' (NPF–2)* *'Firms occasionally collaborate with competitors in the ecology field to advance shared environmental objectives and develop best practices. This collaborative approach accelerates the achievement of industry-wide sustainability goals' (Synthesised insights)* *'Collaborating with other sectors to share best practices and develop unified standards can enhance the overall effectiveness of sustainability initiatives' (NPF–9)* *'We have played a role in contributing to the solar energy UK good practice guidance, designed to assist solar companies throughout the project cycle with a focus on improving biodiversity at each stage' (NPF – 6)*

	Cross-sectoral collaboration for innovation and influence	• Partnering with academia and ecological experts • Influencing investment markets through ESG innovation • Creating ESG benchmarks with financial sector • Aligning cross-sector knowledge for compliance and impact • Codifying best practices through shared learning	*'…sharing findings and collaborating with academic institutions enhances environmental science and provides educational opportunities… [helping] farmers understand the importance of biodiversity management that can foster better compliance with management plans and improve ecological outcomes' (NPF – 7)* *Banks are early adopters or first movers in ESG and sustainability, which gain a competitive advantage over those that are only now starting to focus on these areas (NPF– 5)* *'The impact of cross-sectoral collaboration is also evident in the finance sector. Financial institutions, as early adopters of ESG standards, influence the broader market by collaborating with other sectors, such as regulators, industry groups, and businesses, to establish benchmarks that drive sustainability initiatives' (NPF–5)* *'…collaborating with other sectors to share best practices and develop unified standards can enhance the overall effectiveness of sustainability initiatives' (NPF–9)* *'We have played a role in contributing to the Solar Energy UK good practice guidance, designed to assist solar companies throughout the project cycle with a focus on improving biodiversity at each stage'. (NPF–6)*

	Community engagement and public legitimacy	• Engaging local expertise and community specialists • Delivering environmental education and outreach • Maintaining low-level, ongoing communication • Framing biodiversity as a public good	*'…we involve local experts, such as water specialists, bird specialists or community engagement professionals, to make sure we address all necessary actions…' (NPF–1)* *'…we support local schools and the community by conducting training sessions and educational activities… collaborate with local green groups to run environmental sessions…' (NPF–7)* *'…we maintain ongoing discussions about the value of nature, opportunities for biodiversity net gain, and the societal benefits of these efforts… Through continuous, low-level communication, we aim to consistently highlight the benefits of enhancing nature' (NPF–6)* *'…we also explore how specific species can thrive with targeted site improvements… this clarity is highly practical and effective… The societal benefits of these efforts reinforce the notion of nature as a shared community value' (NPF–6)*

Policy engagement and compliance (PEC)	Compliance as a strategic asset	• Framing compliance as financial opportunity • Participating in shaping industry-wide policy guidance • Avoiding risk through regulatory foresight • Leveraging existing compliance frameworks for efficiency	*‘Trading surplus biodiversity [units could] offer a new revenue stream… [while] demonstrating leadership in environmental compliance’ (NPF–8)* *‘…we work with industry bodies like Solar Energy UK to provide guidance on biodiversity management for the whole industry…’ (NPF–6)* *‘Proactively engaging with ecological regulations also helps firms avoid costly delays or legal repercussions… there are several established precedents available… we have our own internal repository of agreements that we can draw upon…’ (NPF–8)*

	Internal governance and ESG-policy integration	• Implementing robust ESG-aligned legal frameworks • Mitigating non-compliance risks through legal design	*‘We offer specialised legal and regulatory advice in negotiating contracts and arranging debt financing to ensure financial stability and compliance, which are essential for project success…’ (NPF–11)* *‘We maintain a clear separation between the board and the executive committee to ensure effective management and operational efficiency; implementing comprehensive governance frameworks including oversight by non-executive directors and chairs maintains accountability and transparency’ (NPF–11)*

Table 3: Inter-firm activity themes in value creation

Inter-firm Activity	Instrumental Value	Integrative Value	Ecosystem-based Value
Investor relations management (IRM)	● Delivering biodiversity-aligned outcomes ● Attracting responsible investments ● Simplifying investment structures	● Addressing investors' implicit needs ● Building operational transparency with investors ● Structuring strategic ESG responses	
Strategic and operational management (SOM)	● Market differentiation ● Risk management through transparency ● Efficiency and cost-effectiveness ● Customer satisfaction	● Proactively ethical client engagement ● Embedding authentic sustainability in business models	
Biodiversity and nature-positive initiatives (BNI)		● Ecological reporting and outcome communication ● **Integrated land use and nature-positive design**	● Ecological assessment and management planning ● **Integrated land use and nature-positive design**
Collaboration and community impact (CCI)		● Inter-firm collaboration with the industry ● Cross-sectoral collaboration for innovation and influence ● **Community engagement and public legitimacy**	● **Community engagement and public legitimacy**
Policy engagement and compliance (PEC)	● Compliance as a strategic asset	● Internal governance and ESG-policy integration	

Table 4: Synthesising Value, Challenge, Opportunity and Tension

Biodiversity Value Themes	Challenges	Opportunities	Tension
Instrumental Orientation *Biodiversity as a strategic tool for reputation, investment, compliance and efficiency*	● Lack of biodiversity expertise and awareness in business and finance domains ● Inconsistent biodiversity metrics and reporting frameworks ● Limited availability of investable nature-positive assets ● Resource constraints, particularly in small firms	● Enhanced ESG profile to secure tenders and attract investors ● Integration of biodiversity into financial instruments (e.g., green bonds, biodiversity credits) ● Operational efficiencies from sustainable land management ● Monetisation via Payments for Ecosystem Services (PES) and biodiversity-linked DCF modelling	● Pressure to deliver short-term financial returns over long-term biodiversity outcomes. ● Simplified biodiversity metrics may miss nuanced ecosystem impacts ● Trade-offs between market performance and ecological credibility
Integrative Orientation *Embedding biodiversity within governance, stakeholder engagement and adaptive management practices*	● Operational inconsistencies in biodiversity practices across projects ● Fragmented communication among stakeholders and fund managers ● Limited landowner training and ecological understanding	● Stakeholder-driven innovation ● Co-creation of value ● Enhancement of inter-organisational alignment	● Traditional land use practices conflicting biodiversity requirements ● Commercial confidentiality vs. public transparency ● Balancing stakeholder co-design with operational control

	• Gaps in adaptive management and feedback loops		
Ecosystem-based Orientation *Recognising nature’s intrinsic value and restoring ecosystem function and resilience*	• Weak systemic enforcement for ecological restoration • Supply chain impacts (e.g., mining, sourcing and manufacturing) • Biodiversity treated as offset rather than embedded priority	• System-wide innovation and policy development • Biodiversity Net Gain (BNG) reframed as strategic opportunity • Growth of biodiversity-focused markets (e.g., eco-tourism, farmland) • Development of new assessment frameworks • Cross-sector learning through focus groups, industry engagement	• Overreliance on offsetting mechanisms vs. site-level enhancement • Complexity of ecological accounting vs. desire for simple metrics • Ecosystem stewardship may conflict with fast-paced development cycles

Figure 1: Biodiversity Value Data Structure

Figure 2: Inter-firm Activity Themes and Influence

Figure 3: An Integrated Model of Biodiversity Strategy