Assessing knowledge gaps in biodiversity economics and finance

A preliminary report

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The Western Australian Biodiversity Science Institute

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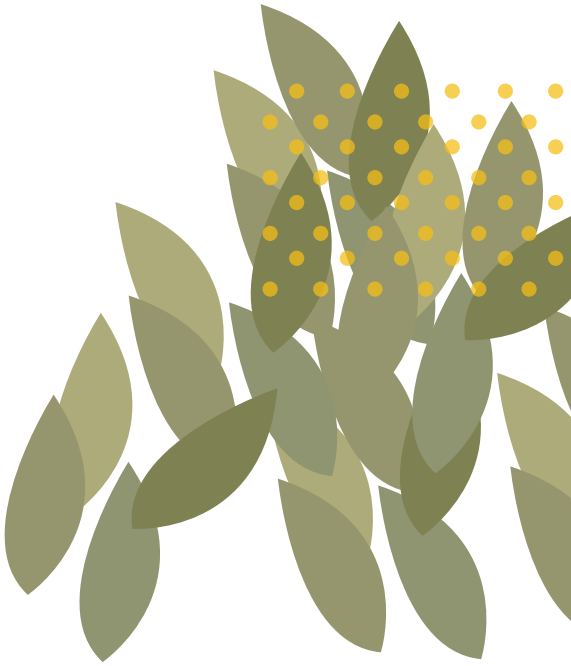
Prepared by:

Ram Pandit and Dinesh Babu Thapa Magar

The Western Australian Biodiversity Science Institute



Acknowledgement of Country

We acknowledge the traditional custodians throughout Australia and their continuing connection to, and deep knowledge of, the land and waters. We pay our respects to Elders both past and present.

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Contents

List of Tables

List of Figures

List of Appendices

1. Executive summary

The work of The Western Australian Biodiversity Science Institute (WABSI) is informed by active engagement with stakeholders to identify end user knowledge needs and priorities. WABSI's consultations with government, industry and community end users in 2022 identified several key themes and emerging issues for Western Australian biodiversity science, including measuring biodiversity, valuing biodiversity, and incorporating traditional knowledge and values in biodiversity conservation, among others (WABSI, 2022). Global drivers and pressures for improved biodiversity outcomes have informed these priorities, including the targets set by the Convention on Biological Diversity (CBD) Conference of the Parties (CoP) 15, i.e. the Kunming-Montreal Global Biodiversity Framework (KMGBF).

WABSI develops targeted research programs to address these knowledge priorities. A new program focusing on biodiversity economics and finance commenced in 2024. It focuses on a) understanding, measuring, and valuing biodiversity, and b) exploring mechanisms to finance biodiversity conservation, including emerging developments on biodiversity markets, nature positive journey, and nature-related Environmental, Social and Governance (ESG) reporting.

In this context, this preliminary report aims to identify knowledge gaps in biodiversity economics and finance to mainstream biodiversity in private and public decision-making. It takes a multi-pronged approach to identify knowledge gaps: a) systematically reviewed the global literature – both peer-reviewed and grey, b) focused review of Australian and Western Australian literature, and c) stakeholders consultations to understand emerging issues, challenges, and knowledge gaps in biodiversity economics and finance.

In identifying the knowledge gaps, in general, we found that peer-reviewed literature is more focused on biodiversity economics, and grey literature on biodiversity finance. Literature on biodiversity finance has been emerging rapidly in the last few years, particularly in the lead up to COP 15, to finalise the KMGBF.

There is greater realisation across all sectors that biodiversity loss is a material and financial risk to the economic system and to existing business models. As a result, there is a growing interest among industry to assess impacts, dependencies, risks, and opportunities in relation to nature and biodiversity. Given the context-specificity of biodiversity, several widely applicable and scalable measurement approaches, tools, and frameworks are in the early stages of development and application (Table 1).

To achieve goals and targets set by the KMGBF, a transformational shift in the way markets value nature, nature-based assets, and natural capital along with alignment of private and public financial flows is essential.

Historically, biodiversity financing is primarily done by the public sector. The scope of philanthropic, private, and blended financing models is rapidly increasing. A range of financing model specific policy instruments are available for practice (Figure 4), but their effectiveness in achieving biodiversity outcomes is not yet fully explored.

Peer-reviewed and grey literature highlight a range of biodiversity economics and finance related knowledge gaps. Key knowledge gaps related to biodiversity economics include a) conceptualisation and understanding of biodiversity values, b) biodiversity data, valuation methods, and tools, c) policy uptake of valuation results and leveraging transformation, d) effect of biodiversity on ecosystem functioning, and biodiversity conservation and management.

Similarly, key knowledge gaps related to biodiversity finance include a) policies, regulations, institutions, and their impacts, b) biodiversity-related financials risks and costs, c) biodiversity metrics and measurement techniques, d) financing options, mechanisms, financial flows, their impacts and scaling pathways, and e) reporting of corporate nature-related impacts, dependencies, risks, and opportunities.

Knowledge gaps identified in the general literature are mostly applicable to Australia and Western Australia with some specific aspects covered by the Australian literature. Some of the knowledge gaps identified in the Australian literature include a) simple and flexible but robust and scalable measurement metric for biodiversity, b) ways to define and measure sustainability across different sectors, c) identification of reliable indicators, methodologies, and assumptions to evaluate nature-related impact, dependency, and risk, d) effective strategies to address nature-related material risks and opportunities identified by the businesses in their operational and portfolio levels, e) effective utilisation of data to integrate nature-related issues into decision-making by financial institutions, such as banks, super funds, f) understanding full economic value and benefits of natural capital to embed them into financial decision-making for diverse stakeholders (e.g., farmers, landholders, indigenous land owners and managers, tourism operators, and businesses).

For Western Australia (WA), the known knowledge to manage and conserve its unique biodiversity is inadequate given its high rates of endemism. Some key areas needing knowledge generation for WA include: a) understanding and measuring biodiversity using scalable measurement metrics and frameworks; b) tools and decision-making frameworks to embed biodiversity values adequately in decision-making by both industries and governments; c) developing standardised methods that accommodate uncertainties to incorporate mineral resources (or other sectoral resources) in natural capital accounts; d) integrating natural capital accounts with financial systems for different sectors; e) approaches to value biodiversity by avoiding double counting; f) criteria and ways for materiality assessments (single and double) for different sectors, h) assessment of the impact of biodiversity management or nature-related actions, policies, and products, and i) scalable tools or approaches to assess impacts, dependencies, risks, and opportunities in relation to biodiversity or nature across various sectors.

Stakeholder consultation reinforced some of the knowledge gaps identified from the literature. Stakeholders have unique perspectives on knowledge gaps based on the interface of their operations with biodiversity. Broadly, stakeholders indicated biodiversity or nature-related knowledge gaps to improve an understanding to measure and value biodiversity, to find scalable and dependable models to finance nature and biodiversity, and to develop an enabling environment to embed biodiversity in economic and financial decision-making of business and government. These knowledge gaps are related to a perception of biodiversity and nature positive; data, measurement metrics, models, and frameworks; the design and function of a biodiversity market, including demand- and supply-side determinants; and effective ways of financing biodiversity conservation.

These findings imply that whole of government and inclusive corporate approaches would be needed in economic and financial decisions by both public and private sectors by identifying impacts, dependencies, risks, and opportunities in relation to biodiversity or nature. To progress this, sector-specific consultations would need to be undertaken to help identify and prioritise WA-specific knowledge gaps at finer scales. This prioritisation process forms part of the WABSI program development pathway. This approach will help address knowledge priorities, and in tandem with other WABSI programs, will enable biodiversity outcomes for Western Australia for progress towards nature positive.

2. Introduction

Nature contributes to human wellbeing. It is inseparable from economic activities. However, the state and extent of nature is rapidly degrading and depleting, and, in turn, affecting economic activities and human wellbeing negatively. Like other forms of capital - financial, human, social, and technical, nature is also a form of capital (natural capital). Natural capital refers to the stock of renewable and non-renewable natural resources (e.g., plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people or ecosystem services or abiotic services, which underpins human societies, economies, and institutions by regulating the critical environmental conditions (Natural Capital Coalition et al., 2018). Maintaining harmony and balance of stocks and flows within and across these capitals is required for economic progress and improved human wellbeing.

Biodiversity[1] is a sub-set of natural capital, a portfolio of assets, a characteristic of ecosystems, a final ecosystem service[2] or a good in itself (Mace et al., 2012). Biodiversity is important for the resilience, adaptability, and productivity of living and non-living elements of nature. It enhances the resilience of ecosystems to shocks, regulates ecosystem functions and processes, and enables ecosystems to flourish and supply wide range of services that contributes to human wellbeing (Figure 1) (Dasgupta, 2021; NGFS, 2023a; World Bank, 2021). Biodiversity is both integral to and essential for natural capital's services (Natural Capital Coalition et al., 2018). In this sense, biodiversity is the building block, ecosystem functions are the processes, and ecosystem services are the products of ecosystems. Preventing biodiversity loss and maintaining stocks of natural capital is crucial, as they allow for the sustained provision of the flows of ecosystem services like interest or dividends from those stocks, and thereby ensuring enduring human wellbeing (Dasgupta, 2021; TEEB, 2010). Many of the ecosystem products are commodities with values in marketplace, but many of them are also public goods—nonrival, nonexcludable, freely accessible, and with no easy translation into market value (Brauman et al., 2007).

Human society, economies, and financial systems are embedded in nature, not external to it (Dasgupta, 2021; TNFD, 2023). The existence, prosperity and resilience of human societies and economies depend on the health and resilience of nature and its biodiversity (NGFS, 2023a; TNFD, 2023). In 2020, estimated US$44 trillion of economic value generation – over half of global gross domestic product (GDP) – was moderately or highly dependent on nature and its ecosystem services (WEF, 2020). A recent study estimated that about US$58 trillion — equivalent to 55% of global GDP — is moderately or highly dependent on nature and natural ecosystems (Evison et al., 2023). There is a significant dependence of 85% of the world's largest companies listed in the S&P Global 1200 Index on nature for their direct operations (Whieldon et al., 2023).

The loss of biodiversity undermines the ability of nature to provide ecosystem services on which human society and economies rely (NGFS & INSPIRE, 2022). Nevertheless, the lack of market for many ecosystem services and the lack of individual incentives or compensation mechanisms to halt their degradation is often contributing to the ongoing degradation of these services (MEA, 2005).

The Economics of Biodiversity by Dasgupta (2021) examines why societies fail to manage biodiversity assets effectively and aims to identify the changes that could improve management practices. The reasons behind societal failure to manage and search for ways to improve biodiversity management are intrinsically connected to people's values for nature and valuation methods. People's values for nature are crucial in nature-related decision-making and decisions that impact people and nature in complex ways (Vatn et al., 2024). Knowledge and operationalisation gaps in values and valuation of nature are believed to hinder the integration of nature's values into decision-making processes (IPBES, 2022a). Additionally, biodiversity valuation is the fundamental and necessary step towards developing suitable biodiversity finance mechanisms and, in turn, effective decision-making (De Valck & Rolfe, 2019). Therefore, identification of knowledge gaps in values and valuation of biodiversity would be vital for streamlining future research and actions, as well as fostering the integration of the diverse values of nature into decision-making processes aiming at transformative change (IPBES, 2022a). In this report, the focus on understanding knowledge gaps in biodiversity economics is primarily centred around identifying knowledge gaps in understanding and measuring the values of biodiversity.

[1] Biodiversity is defined as the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; and includes diversity within species, between species and of ecosystems (CBD, 1992).

[2] Ecosystem services are material and non-material benefits provided by ecosystems to humans (MEA, 2005). They are nature's direct and indirect contributions to human wellbeing or nature's contribution to people (Costanza et al. ,1997; Díaz et al., 2018). They include provisioning services, such as food, raw materials, and fresh water; regulating and maintenance services, such as climate, water and air quality regulation, pollination, and pest and disease control; and cultural services, supporting recreation, mental and physical health, and spiritual and religious values (Dasgupta, 2001; NGFS & INSPIRE, 2022). Underpinning these are the supporting services such as soil formation, photosynthesis, primary production, nutrient cycling, and water cycling (MEA, 2005).

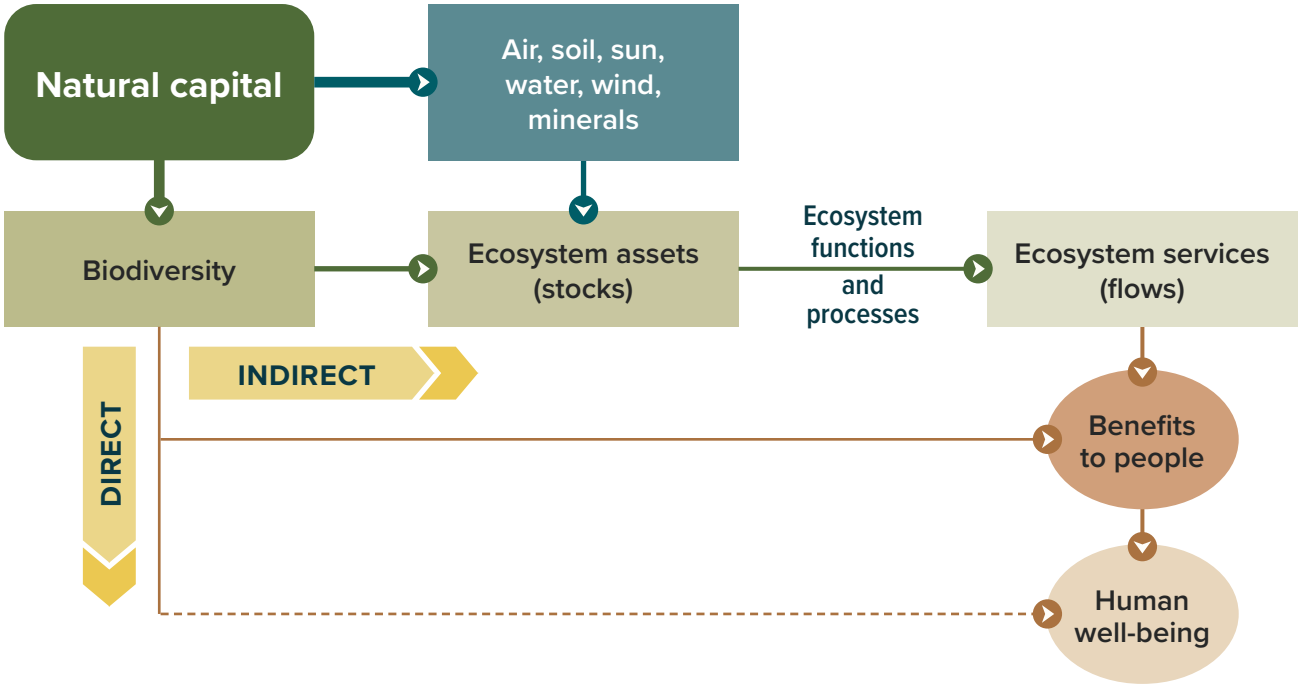

Figure 1. The conceptual link between natural capital, biodiversity, and human well-being

Similarly, biodiversity finance has emerged as a fast-growing area with increased interest in financing the transition to nature-smart economic activity from investors, financial institutions, and bond issuers globally (IFC, 2023). It refers to the practice of raising and managing capital and using financial and economic incentives to support sustainable biodiversity management (UNDP, 2018).

Studies estimate that halting biodiversity loss requires annual funding ranging from US$722 billion to US$967 billion, approximately seven times the current investment levels, i.e. $124 to $143 billion in 2019 dollar (Seidl et al., 2024). The Kunming-Montreal Global Biodiversity Framework (KMGBF) estimates an annual biodiversity finance gap of US$700 billion through 2030 and aims to close this gap through raising around US$200 billion in new funding and repurposing US$500 billion of harmful subsidies under Target 19, emphasising a *whole of society approach*, including involvement of private sectors such as financial institutions in meeting its goals and targets (CBD, 2022).

Additionally, Target 15 of the KMGBF calls for businesses to monitor, assess and transparently disclose their risks, dependencies and impacts on biodiversity, to ensure harmony between business, society, and nature (TNFD, 2023). Various mechanisms and initiatives are also rapidly developing at both global and national levels to facilitate biodiversity-aligned financial flows from diverse sectors and improved corporate disclosures on biodiversity impacts and dependencies, such as Taskforce on Nature-related Financial Disclosures (TNFD). In the background section, Figure 5 shows the links between biodiversity, ecosystem services, economic activity, nature loss, nature-related financial risk and corporate disclosure framework, and Figure 6 presents the timeline of major initiatives and events along with other significant milestones in mainstreaming biodiversity in decision-making. Understanding knowledge gaps and future research needs in biodiversity finance would be vital for guiding future efforts and integrating biodiversity into financial decisions and aligning financial flows accordingly.

Overall, understanding the gaps in biodiversity economics and finance would be vital for informed decision-making as well as formulating strategies and actions for a diverse range of stakeholders towards mainstreaming biodiversity and addressing the various challenges associated with biodiversity loss. Mainstreaming biodiversity is the process of embedding biodiversity considerations into policies, strategies and practices of key public and private actors that impact or rely on biodiversity, so that biodiversity is conserved, and sustainably used, both locally and globally (Huntley & Redford, 2014).

Against this backdrop, this review was conducted with the aim of identifying the knowledge or research gaps, or future research needs, with a focus on both biodiversity economics and biodiversity finance. The review was done by assessing the peer-reviewed and grey literature, and consulting with end uses and other relevant stakeholders engaged in making decisions in relation to conserving or managing biodiversity or nature.

Data and methods are presented in section 3, key findings of the review in section 4, followed by relevant background in section 5, including the state of biodiversity and associated regulatory and policy developments in Australia and Western Australia. Finally, we outline the next steps in the development of the biodiversity economics and finance program to address end user knowledge priorities.

3. Data and methods

3.1 Systematic literature review

To identify the research gaps or knowledge gaps or future research needs in biodiversity economics and finance, we reviewed both peer-reviewed as well as grey literature. For the peer-reviewed papers, we adopted a systematic literature review approach with a focus on selected databases and title search[3]. In June 2024, we conducted a search on electronic journal databases, namely, SCOPUS, Web of Science, and EconLit using seven search terms (or keywords) – 'valuation of biodiversity' OR 'biodiversity valu*' OR 'biodiversity economics' OR 'economics of biodiversity' OR 'biodiversity financ*' OR 'nature financ*' OR 'conservation financ*' to cover both biodiversity economics and biodiversity finance. These search terms were applied to the article title from the year 2010 onwards. The choice of 2010 as a cut-off year is to coincide with the UN declaration strongly related to biodiversity. UN declared 2010 as the International Year of Biodiversity and 2011 –2020 as United Nation's Decade on Biodiversity. The title search generated a total of 206 articles – 17 from EconLit (EBSCOhost), 88 from Web of Science, and 101 from SCOPUS. This number was reduced to 100 after excluding 103 duplicate articles, two non-English articles, and one irrelevant article (Figure 2).

We read and closely examined the abstract and conclusion sections of each paper. We also scanned the full text for any mention of 'research gap' or 'knowledge gap' or 'future research need'. Out of the total papers reviewed, 80 papers were relevant to biodiversity economics, of which 34 papers included one or more research or knowledge gaps in biodiversity economics; and 13 were relevant to biodiversity finance, with 12 of them reporting one or more research gaps or future research needs in biodiversity financing. On the other hand, only seven papers were found to cover both aspects of the review, of which three papers presented research gaps related to both biodiversity economics and finance. The 'research gaps' or 'knowledge gaps' or 'future research needs' specified in these papers were documented and synthesised. Additionally, following snowball sampling approach, we reviewed other relevant articles that were cited by the reviewed papers but not identified in the systematic search. Appendix 1 provides the list of literature reviewed.

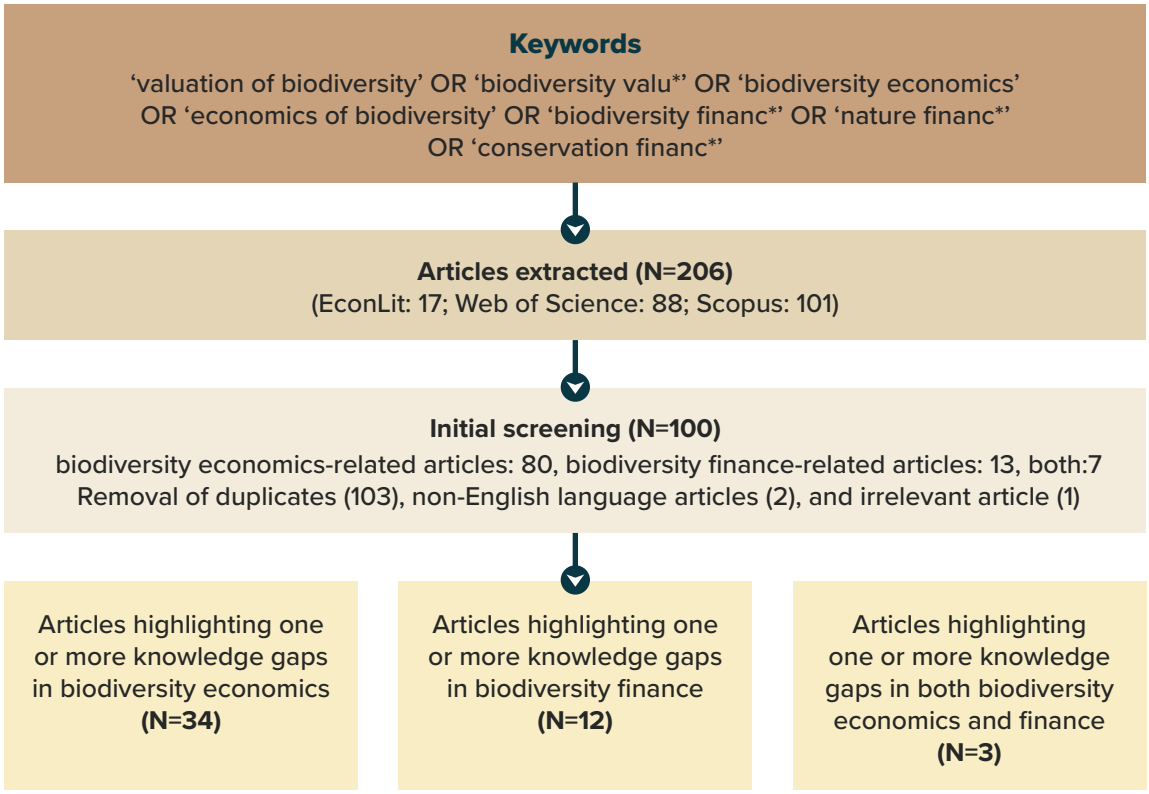

Figure 2. Flow chart of the systematic literature review process

[3] We focused on title search to make the search targeted by limiting the number of hits.

3.2 Grey literature review

We also reviewed grey literature to understand the rapidly evolving state of knowledge and the 'knowledge gaps' or 'research gaps' or 'future research needs' in biodiversity economics and finance. Considering the involvement of various stakeholders — public, private, community, and philanthropic organisations — at different levels in addressing diverse nature- or biodiversity-related issues, we reviewed publications related to biodiversity economics and finance emerging from global, national, and local initiatives and organisations, including CBD, World Wildlife Fund (WWF), United Nations Environment Programme Finance Initiative (UNEPFI), World Economic Forum (WEF), Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), Taskforce on Nature-related Financial Disclosures (TNFD), just to name a few. Given the proliferation of grey literature in recent time, particularly on biodiversity finance, we followed snowballing approach and targeted search from the insights gained from reviewed literature to track additional grey literature. In addition, we also followed the grey literature recommended by the stakeholders we consulted. Appendix 2 provides the details on grey literature we reviewed[4].

3.3 Stakeholder consultations

We also consulted a range of organisations, stakeholders, and experts – mostly from Australia and Western Australia – working on biodiversity and nature or have stake on them from research institutions (e.g., universities and CSIRO), financial institutions (e.g., Western Australian Treasury Corporation, banks, investment/asset management firms, consulting firms – PwC, KPMG, Pollination), government agencies (e.g., Department of Biodiversity Conservation and Attractions, Department of Primary Industries and Regional Development, Department of Water and Environmental Regulation), businesses (e.g., BHP, Alcoa, Hanson, Rio Tinto), Aboriginal-focused organisations (e.g., ARC centre for Healing the Country), Natural Resource Management organisations (e.g., South Coast Natural Resource Management, Perth NRM), and some international organisations (such as World Economic Forum, World Biodiversity Forum, James Hutton Institute, and University of Nottingham) to gain additional insights, perspectives, and understanding on research needs in biodiversity economics and finance.

In addition, Appendices 3 and 4 provide details of the peer-reviewed and grey literature we reviewed to explore knowledge gaps in biodiversity economics and finance for Australia and Western Australia, respectively. In Appendix 5, we provide the type and number of stakeholders consulted.

[4] We acknowledge the limitation of our approach of assessing grey literature, which is not easily replicable and could miss some pertinent grey literature.

4. Key findings

The key findings of the review are presented in sequence. First, we present and discuss the findings on biodiversity measurement and disclosure (sub-section 4.1), followed by biodiversity finance landscape (sub-section 4.2). We then synthesise the knowledge gaps or research needs in biodiversity economics and finance in subsequent sections. In presenting the knowledge gaps, we first present general knowledge gaps in biodiversity economics and finance based on peer-reviewed and grey literature (sub-sections 4.3 and 4.4). Then we focus on such knowledge gaps for Australia and Western Australia (sub-sections 4.5 and 4.6). Finally, we present the knowledge gaps based on stakeholder consultations (sub-section 4.7).

4.1 Biodiversity components, metrics, measurement approaches, and disclosure initiatives

Biodiversity is a complex concept that encompasses species diversity, their genetic diversity, and their interactions with each other and their environment, making it challenging to clearly define, measure, manage, and conserve (Harrer et al., 2023). Nevertheless, there is growing awareness among businesses, financial institutions, and policymakers of the risks posed by the loss and decline of biodiversity and the opportunities for positive action (UNEP-WCMC et al., 2022), including a consensus among various stakeholders on the need to halt or reverse the loss of biodiversity to restore balance among ecosystems (Harrer et al., 2023). However, halting biodiversity loss by governments alone is impossible without effectively engaging businesses and financial sectors, and fostering cross-sector collaboration. Such engagement and collaboration are vital for providing the resources needed for conservation and bridging the biodiversity funding gap. The assessment of *double materiality*[5] by businesses and others, and increased funding for biodiversity conservation would be one of the ways to bridge the funding gap (Harrer et al., 2023; World Bank Group, 2020).

Businesses are currently facing growing pressures to measure and report their impacts and dependencies on biodiversity, as well as natural capital, climate, and social responsibilities (UNEP-WCMC et al., 2022). These pressures are driven by national and regional policy and regulatory developments, international agreements, resolutions, policies and targets (such as the post-2020 global biodiversity framework or KMGBF, and the UN resolution on the human right to a healthy environment), market forces, reputation, operational efficiencies, and access to finance (UNEP-WCMC et al., 2022). Unlike the carbon indicator for climate targets and assessments, describing the state of biodiversity with a single metric is unlikely to be possible or credible. Additionally, biodiversity measurement and valuation vary by business needs and operational scales, requiring different accuracy levels, measurement frequencies, assessment boundaries, and posing challenges in data availability and quality (UNEP-WCMC et al., 2022). Therefore, a complex landscape of metrics, tools and frameworks have been (or are being) developed with the aim of supporting investors and companies to understand, capture, and appropriately address and disclose their biodiversity impacts and dependencies (ACSI, 2021; UNEP-WCMC et al., 2022).

The state of biodiversity is determined by impact drivers (i.e. activities that affect biodiversity) and dependencies (i.e. the reliance of economic activities on biodiversity) in a given context. Measurement indicator (or metric) of biodiversity depends on its type and components (Figure 3). For example, metric for species diversity could be number of individuals if the focus is on population size of the species, whereas it could be a change in species area habitat if the focus is on global extinction risk of the species.

There are several metrics to measure species and ecosystem diversity, and fit-for-purpose type of metrics are still evolving. Different metrics can be used to measure same biodiversity depending on the type of information needed. Table 1 (column 1) provides a non-exhaustive list of biodiversity metrics that are in practice. In parallel, biodiversity measurement approaches, techniques, tools, and frameworks are also rapidly evolving. There is no single approach that is universally accepted for biodiversity measurement unlike the one for carbon (i.e., CO_2 equivalent). Table 1 (column 2) provides compilation of measurement approaches and their developers. Similarly, different types of frameworks provide methodology or guidance to assess impacts and dependencies, to set targets, and to report disclosure on impacts, dependencies, risks, and opportunities. Table 2 provides a compilation of such frameworks for biodiversity assessment, target-setting, and disclosure purposes.

[5] Double materiality refers to both the impact of environmental risks and opportunities on business performance and financial position, and the effects of business activities on the environment and society.

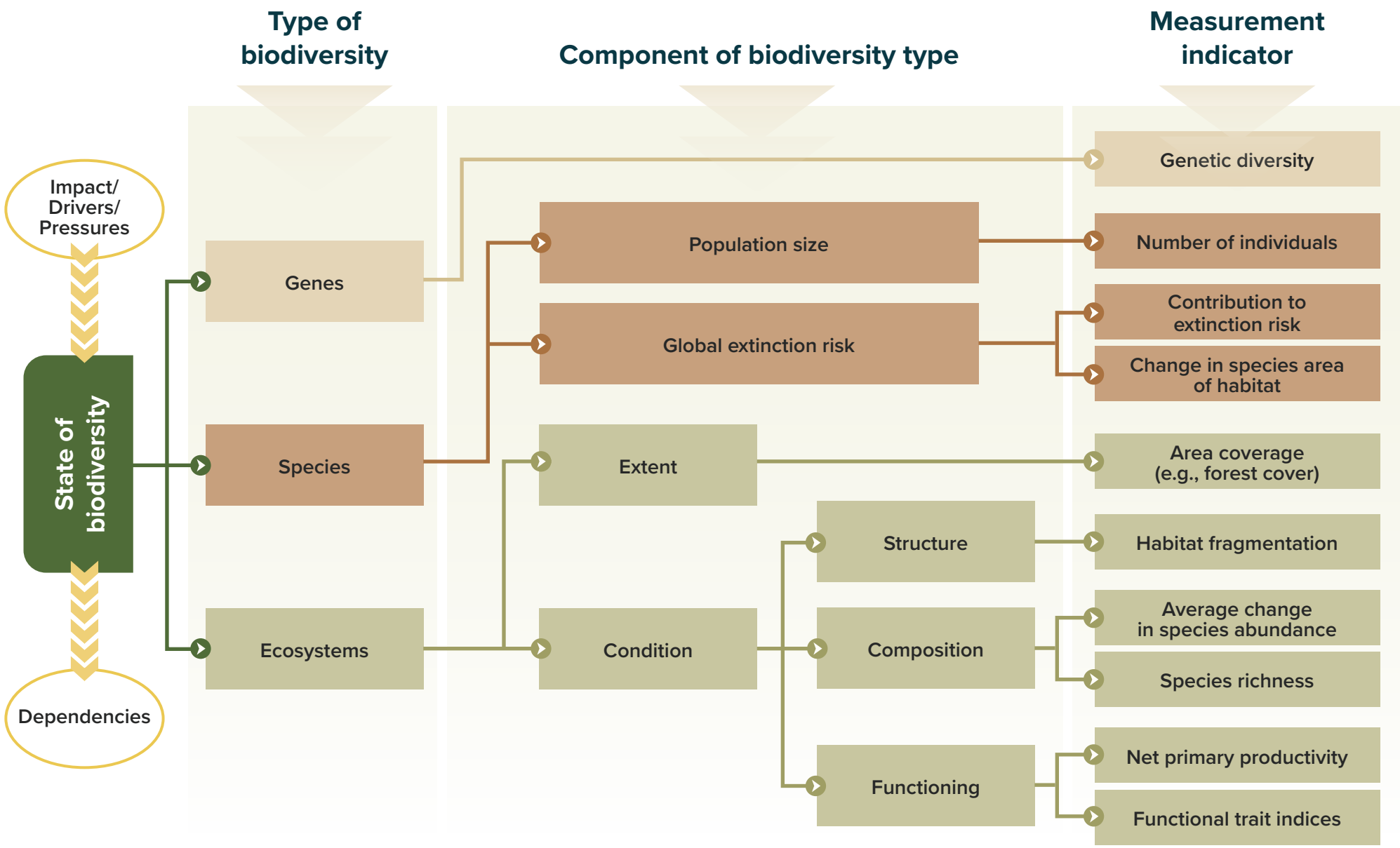

Figure 3. Components of biodiversity and measurement indicators (example)
(Source: UNEP-WCMC et al., 2022)

Table 1. Biodiversity metrics and measurements approaches

Biodiversity indicators or metrics	Biodiversity measurement approaches	
Biodiversity indicators or metrics measure different elements (like species, ecosystem intactness, ecosystem benefits) and can be used to answer different questions.	Biodiversity measurement approach encompasses metrics (standardised measure), data/models, tools, and frameworks, which can be used to assess biodiversity impact and dependencies. Note: Text in the *italicised parenthesis* refers to the developer(s) of the measurement tool/approach	
Species metrics: • Number of individuals • Species Threat Abatement and Restoration (STAR) metric ***Extent-Condition metrics*** • Habitat hectares • Quality hectares • Mean Species Abundance (MSA) • Potentially Disappeared Fraction (PDF) ***Extent-Condition Significance metrics:*** • Biodiversity Intactness Index (BII) • Biodiversity Impact Metric (BIM) • Site Biodiversity Condition Class • Biodiversity Net Gain Metric • Biodiversity Score **Thematic metrics:** • Deforestation free commodities or supply chains • Surface of regenerated or restored land • Agrobiodiversity Index (ABDI) **Financial metrics:** • Environmental Profit & Loss accounts (EP&L) **Combined state, pressure, and response metrics:** • No single quantitative metric • Score cards used to identify risk areas • Appreciation of progress (e.g. colour codes, arrows)	• **Agrobiodiversity Index (ABDI)** *(Alliance of Biodiversity International and CIAT)* • **Biodiversity Assessment Method (BAM)** *(The State of NSW and DPIE)* • **Biodiversity Footprint Financial Institutions (BFFI)** *(ASN Bank; CREM; PRé Sustainability)* • **Biodiversity Footprint Methodology (BFM)** *(SarVision; Plansup)* • **Biodiversity Impact Assessment Tool (BIAT)** *(ISS ESG)** • **Biodiversity Impact Metric (BIM)** *(Cambridge Institute of Sustainable Leadership (CISL)* • **Biodiversity Indicator and Reporting Ecosystem and Ecosystem Services Assessment (BIRS and ES assessment Holcim)** *(Ecoacsa; Holcim)* • **Biodiversity Indicators for Site-based Impacts (BISI)** *(UNEP-WCMC; Conservation International; Fauna & Flora International)* • **Biodiversity Integrated Assessment and Computation Tool** *(B-INTACT) (FAO)* • **Biodiversity Metric 4** *(Natural England UK Department for Environment, Food & Rural Affairs (DEFRA))* • **Biodiversity Monitoring System (BMS) and Biodiversity Performance Tool (BPT)** *(EU LIFE Initiative on Biodiversity in Standards and Labels for the Food Sector)* • **Biodiversity Net Gain Calculator (BNGC)** *(Arcadis)* • **BioScope** *(Ministry of Economic Affairs; CODE; Arcadis; PRé Sustainability)* • **Corporate Biodiversity Footprint (CBF)** *(Iceberg Data Lab)* • **ECOPLAN Scenario Evaluator (ECOPLAN-SE)** *(University of Antwerp; Ghent University; KU Leuven; Flemish Institute for Technological Research; Institute for Nature and Forest Research)*	• **Ecosystem Services Identification & Inventory (ESII)** *(The Nature Conservancy; Dow Chemical Company; EcoMetrix Solutions Group)* • **Environmental Profit & Loss (EP&L)** *(Kering)* • **Exploring Natural Capital Opportunities, Risks and Exposure (ENCORE)** *(UNEP-WCMC)* • **GBS for financial institutions (GBS-FI), including Biodiversity Impact Analytics powered by the GBS (BIA-GBS)** *(CDC Biodiversité; Carbon4Finance)* • **Global Biodiversity Score (GBS)** *(CDC Biodiversité)* • **Global Impact Database (GID)** *(Impact Institute)* • **Integrated Valuation of Ecosystem Services and Tradeoffs (INVEST)** *(Stanford University)* • **LIFE Methodology (LIFE)** *(LIFE Institute)* • **Nature and Biodiversity Metrics (NBM)** *(MSCI)* • **Nature Value Explorer** *(Flemish Institute for Technological Research (VITO))* • **Product Biodiversity Footprint (PBF)** *(I CARE; Sayari)* • **READS** *(Repsol)* • **ReCiPe** *(Radboud University; RIVM; Norwegian University of Science and Technology; PRé Sustainability)* • **Species Threat Abatement and Restoration Metric (STAR) and Integrated Biodiversity Assessment Tool (IBAT)** *(BirdLife International; Conservation International; IUCN; UNEP-WCMC)* • **Toolkit for Ecosystem Service Site-Based Assessment (TESSA)** *(Anglia Ruskin University; BirdLife International; Royal Society for the Protection of Birds; Tropical Biology Association; UNEP-World Conservation Monitoring Centre; University of Cambridge; University of Southampton)*

Source: Lammerant et al. (2022); Lammerant et al. (2024); WEF and Wyman (2024), Bor et al. (2024), and ACSI (2021)

Table 2. Biodiversity assessment, target-setting and disclosure frameworks and initiatives

Assessment frameworks	Target-setting frameworks	Disclosure frameworks
Biodiversity assessment frameworks provide a methodology for assessing the biodiversity impacts and dependencies of an organisation or investor.	Biodiversity target-setting frameworks provide methodology for companies and investors to set meaningful and actionable biodiversity-related objectives and goals.	Biodiversity disclosure frameworks provide methodology for companies to report biodiversity impact, dependencies, risks and opportunities to enable transparent and consistent reporting.
• UN System of Environmental-Economic Accounting (SEEA) • UN System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA EA) • IUCN Guidelines for Planning and Monitoring Corporate Biodiversity Performance • Natural Capital Protocol • Partnership for Biodiversity Accounting Financials (PBAF) Standard • Biological Diversity Protocol • Natural Capital Finance Alliance • EU Aligning Accounting Approaches for Nature (Align Project) • Taskforce on Nature-related Financial Disclosure (TNFD): LEAP (Locate, Evaluate, Assess, Prepare) Approach	• The Global Apex Goal for Nature • International Finance Corporation Performance Standard • UN CBD Kunming-Montreal Global Biodiversity Framework (KMGBF) • European Union Biodiversity Strategy for 2030 and EU Taxonomy • Science-Based Targets for Nature (SBTN)	**Regulatory:** • European Sustainability Reporting Standard on Biodiversity and Ecosystems (ESRS E4), part of the EU Corporate Sustainability Reporting Directive (CSRD) (CSRD ESRS E4) • EU Sustainable Finance Disclosure Regulation (SFDR) • French Energy and Climate Law – i Article 29 (French Art 29) • EU Deforestation Regulation (EUDR) • EU Corporate Sustainability Due Diligence Directive (CSDDD) **Voluntary:** • Disclosure Recommendations and Additional Guidance of the Taskforce on Nature-related Financial Disclosures (TNFD) • Biodiversity Standards of the Global Reporting Initiative (GRI 101: Biodiversity 2024) • Biodiversity Disclosure requirements of CDP (the former Carbon Disclosure Project) • General Requirements for Disclosure of Sustainability-related Financial Information (IFRS S1) (of the International Sustainability Standards Board)

Source: ACSI, 2021; Bor et al., 2024; Lammerant et al., 2022; Lammerant et al., 2024; UNEPFI & UNEP-WCMC, 2021; WEF & Wyman, 2024

4.2 Biodiversity finance landscape

The unprecedented loss of biodiversity, along with the growing recognition of its importance in providing ecosystem services or nature's benefits to society, underscores the urgent need to implement effective conservation policies and mechanisms. However, such policies and mechanisms require financial flows to halt biodiversity loss, while fostering business activities that align with conservation goals. Effective implementation of conservation policies also requires creating enabling environment such as right regulatory mechanisms, smart incentives, and market structures to catalyse both public and private financial flows (Deutz et al., 2020; IPBES, 2022b; UNEPFI, 2023).

Conservation or biodiversity finance is an emerging field that seeks to maximise conservation impacts while generating investor returns. Biodiversity finance flows encompass private and public funds used for conserving and restoring biodiversity, investments in commercial activities that yield positive biodiversity outcomes, and the value of transactions in biodiversity-related markets (UNDP, 2018). However, there is a significant gap between the available finance and what is required to halt biodiversity loss and restore nature (Young & Castro, 2021). For example, Deutz et al. (2020) estimate that global financing for biodiversity conservation amounts to approximately US$124–143 billion annually, with 80–85% of this funding coming from the public sector. But it falls significantly short of the needed US$722–967 billion, leaving a financing gap of US$598–824 billion per year (Deutz et al., 2020). The BIOFIN initiative[6] estimates that the current expenditure on biodiversity accounts for only between 0.03% and 0.94% of GDP, or between 0.14% and 4.60% of the entire public budget, but funding needs on biodiversity conservation are significantly greater (UNDP, 2018). On the other hand, the KMGBF estimates a US$700 billion annual finance gap to be progressively addressed by 2030 through a range of actions: a) eliminating, phasing out, or reforming biodiversity harmful incentives, including subsidies, and repurposing them to generate US$500 billion annually (Target 18); b) aligning public and private activities, resources, and fiscal and financial flows with KMGBF goals and targets, and mobilising US$200 billion annually from various sources, including private sector (Target 19); and c) increasing financial resources progressively from developed countries and those assuming similar obligations to developing and transition economies by at least US$25 billion by 2025 and US$30 billion by 2030 (Target 19) (CBD, 2022).

A transformational shift in the way markets value nature, nature-based assets, and natural capital, along with the alignment of public and private financial flows, is critical to achieve the KMGBF's goal of halting and reversing biodiversity loss by 2030 (FfB, 2024; Karolyi & de la Puente, 2023). Over the past 15 years, there has been a significant emergence, evolution, and development of biodiversity (and ecosystem services) finance compared to earlier efforts on conservation and environmental finance (Seidl et al., 2024). Various actors and approaches from the public and private sectors, including philanthropic efforts, as well as intergovernmental, non-governmental, and multilateral mechanisms, have emerged to address the challenges associated with the biodiversity funding gap (CBD, 2024; Seidl et al., 2024; WEF & Wyman, 2024). The number of innovative nature-related financing mechanisms and products is also growing (WEF & Wyman, 2024).

Figure 3 shows the actors (*who*) and instruments (*how*) for different types of biodiversity financing approaches. The landscape of biodiversity finance is fragmented as demonstrated by diverse financing mechanisms and initiatives that vary significantly in their purpose, scale and size (CBD, 2024). While the development of these mechanisms is encouraging, there is still a significant need for increased funding to meet global biodiversity targets and to further incorporate biodiversity goals into broader policies and frameworks at all sectors and levels (CBD, 2024).

[6] A global partnership managed by UNDP that provides methodologies and strategies for countries to mobilise and manage resources for biodiversity

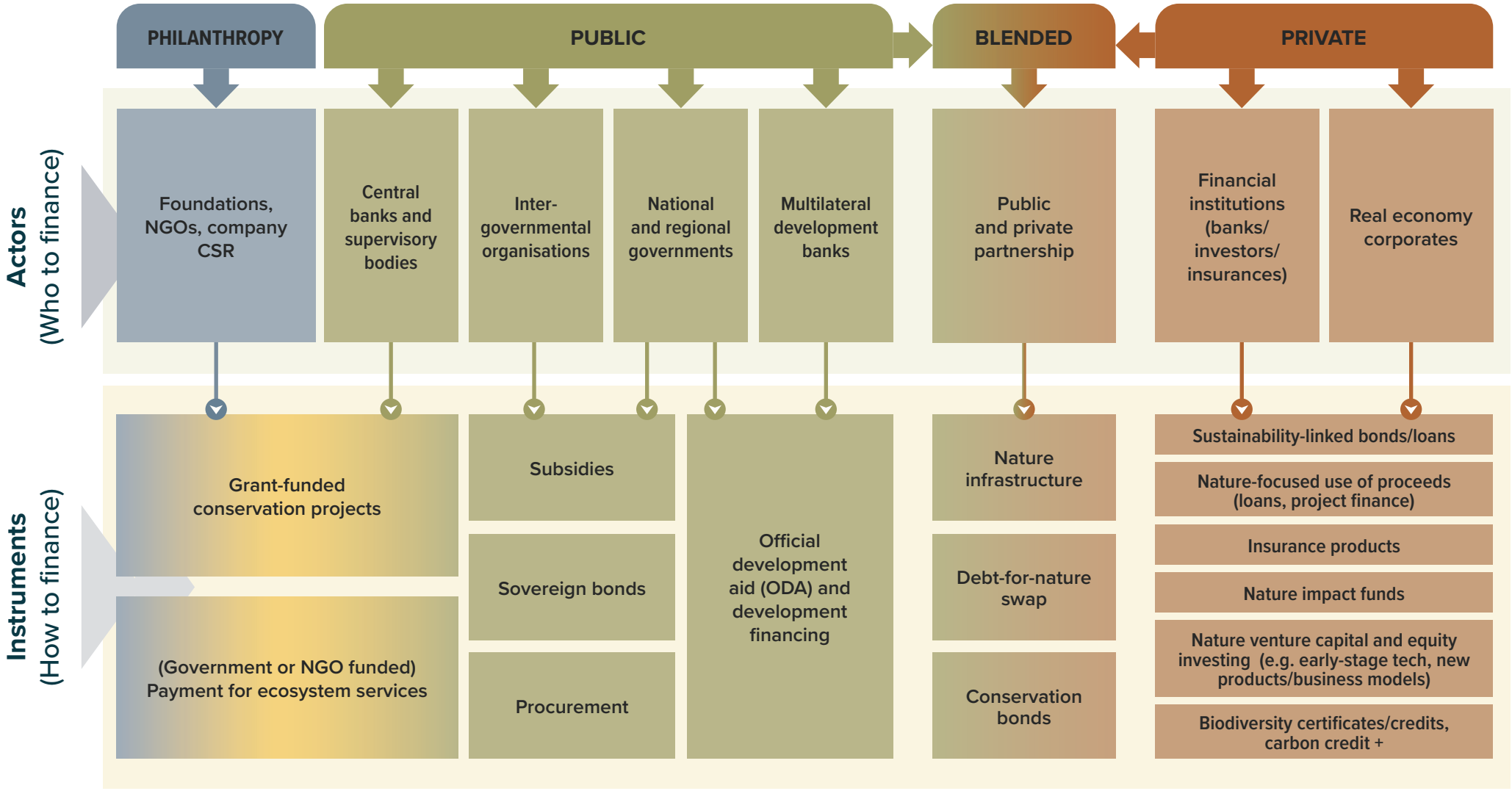

Figure 4. Overview of the different nature-related financing actors and instruments
Source: Adapted from WEF & Wyman, 2024

4.3 Knowledge gaps in biodiversity economics

Knowledge gaps identified in biodiversity economics are primarily related to understanding, measuring, and valuing biodiversity or nature. They are related to wide ranging aspects such as understanding of biodiversity value and current measure of economic progress (i.e., GDP) to valuation tools and policy uptake of valuation findings, for example. These knowledge gaps are grouped into following four categories.

4.3.1 Conceptualisation and understanding of biodiversity values

- Economic growth is generally measured by GDP, which represents the market value of the flow of all final goods and services produced within a country in a given year (Dasgupta, 2021). A substantial emphasis on GDP or instrumental values has further created significant gaps in recognising and understanding other values (non-material, intrinsic, and relational values), as well as their potential to support prosperous economies and invoke care, stewardship and taking responsibility for individual and group-level footprints (Chan et al., 2016; IPBES, 2022b; Pascual et al., 2023).
- Existing research predominantly focus on conceptualising nature's values and their contributions to people mostly through the lens of material values (or instrumental values) (Pascual et al., 2023).
- Biodiversity is the building block for ecosystem processes and functions, which ultimately produces ecosystem services (Mace et al., 2012; MEA, 2005) . The links between biodiversity and ecosystem services and their complex relationships are still not fully understood (De Valck & Rolfe, 2019; Mace et al., 2012).
- Values are likely to change over time due to broader societal changes such as substitution possibilities, income or wealth, education, and cultural change rather than biodiversity-related aspects alone (Strange et al., 2024). However, there is a lack of information about how values form and evolve over time, including the negative values of nature and their potential impact on individual and collective decisions (IPBES, 2022a; Pascual et al., 2023; TEEB, 2010).
- There is insufficient understanding of how different cultures interpret nature, human-nature relationships, and the values they hold for the nature (Brondízio et al., 2021; Wheeler & Root-Bernstein, 2020).
- There is a lack of information on indigenous people and local communities' (IPLCs) knowledge and values, their participation in valuation research, and valuation methods and approaches used by IPLCs (Brondízio et al., 2021; Wheeler & Root-Bernstein, 2020). Since many nature-related decisions occur in the territories and homelands of Indigenous Peoples and local communities who effectively manage much of the world's biodiversity, developing and providing culturally appropriate valuation methods is essential (Termansen et al., 2023).
- Although an increasing number of studies consider various aspects of nature and ecosystem services, including their synergies and trade-offs, which is crucial for unbiased decision-making. However, synergies and trade-offs across ecosystem serviced due to management actions are still poorly understood (Harrison et al., 2014; IPBES, 2022a; Le et al., 2023).
- There is limited understanding on diverse and varied linkages between biodiversity change and human wellbeing (Fenichel & Dean, 2024). This is more prevalent in developing countries (Perrings, 2010) and the Global South, where environmental change and subsequent impacts on the wellbeing of vulnerable populations can be expected to be higher than in Europe and North America (Kosanic & Petzold, 2020).
- Ecosystem and ecosystem services are undervalued and negatively priced due to the provision of widespread and harmful government subsidies on agriculture, energy, water and fisheries (Barbier, 2022; Dasgupta, 2021). More studies are needed to understand how this under-pricing leads to the loss of essential ecosystem services and values, particularly in tropical developing economies (Barbier, 2022).
- There is a lack of knowledge on distortions created by harmful subsidies and similar governmental policies on biodiversity (Karolyi & de la Puente, 2023).
- There is limited research and understanding of the behavioural and motivational aspects of various policy design and implementation features for nature conservation (IPBES, 2022a; Travers et al., 2021).

4.3.2 Biodiversity data, valuation tools and methods

- Availability of data is crucial for the valuation of biodiversity. However, in general, there is a lack of relevant primary data across regions, time, and at the required scale, including for some taxonomic and functional groups as well as in habitat terms to be used for biophysical valuation of nature, especially over large areas (IPBES, 2022a; Orr et al., 2022).
- Despite significant growth in the literature on the economic value of ecosystem services and global coverage by the Ecosystem Services Valuation Database (ESVD) over the past decade, gaps remain in data particularly for certain regions such as South America, North-America and Africa; biomes such as deserts and semi-deserts, subterranean ecosystems, boreal and montane forests and woodlands, shrublands and shrubby woodlands, polar-alpine, and urban and industrial areas; and ecosystem services including disease control, water baseflow maintenance, rainfall pattern regulation, genetic and medicinal resources, spiritual experiences (Brander et al., 2024).
- To date, a quarter of valuation studies have focused on understanding values associated with forest ecosystems followed by cultivated areas and freshwater habitats. Over half of the studies are highly localised generating information about a specific location or species and only 1% have a global outlook (IPBES, 2022a; Pascual et al., 2023), limiting generalization of the results.
- Although there are over 50 distinct methods available for conducting valuation, evidence shows a limited use of the suite of available valuation methods as most studies use only one method (Pascual et al., 2023). Since these methods are highly specific to the types of values they can elicit, studies often fail to capture and report the full range of values involved (IPBES, 2022a).
- Given the range of methods or approaches and their specific limitations and strengths, using a combination of complementary approaches can provide a more comprehensive valuation of diverse values. However, there is a lack of multiple approach-based valuation studies, which require interdisciplinary valuation teams, capacity building in various methods, additional resources, and sensitivity to the appropriateness of methods in different cultural and socio-economic contexts (Chan et al., 2016; Dasgupta, 2021; IPBES, 2022a; Pascual et al., 2023).
- While plural valuation has the potential to drive transformative change by enhancing decision-making processes, incorporating diverse perspectives, reconciling conflicting viewpoints, and enabling new policy tools and institutional arrangements (Zafra-Calvo et al., 2020), there is a limited application of plural and diverse valuation methods and approaches across regions and contexts for valuing non-use and cultural values of nature (IPBES, 2022a; Jacobs et al., 2018; Termansen et al., 2023).
- There is a critical need for deeper understanding on how to effectively adapt plural valuation across various purposes, approaches, and social-ecological contexts in order to contribute to social equity and sustainability (Zafra-Calvo et al., 2020).
- Although integrated valuation methods are developed to capture a broad spectrum of value types, they face difficulties in linking models with varying objectives, computer languages, data requirements, and incompatible parameters, and their successful application in decision-making is still unclear (IPBES, 2022a).
- There is also a significant gap in tracking a wider range of outcomes and understanding their interactions. Many studies lack documentation and chain of evidence to assess whether certain outcomes are primary and require management, while others are secondary and arise as a response to the primary outcomes (IPBES, 2022a).

4.3.3 Policy uptake of valuation and leveraging transformation

- Evidence suggests a limited uptake of values information into policy decisions (Pascual et al., 2023). Additionally, there is a lack of systematic knowledge on uptake of explicit valuation in national and local policy, especially in non-English languages (IPBES, 2022a).
- There are also limited research on the barriers to uptake of explicit valuation outputs in policy cycles, related to the role of power brokerage for valuation knowledge (IPBES, 2022a).
- A significant knowledge gap also includes the lack of information on feasibility and resources needed to perform valuations for different purposes (IPBES, 2022a).
- There is a lack of knowledge on the practice of non-research and non-governmental organisations commissioning valuation consultancies on nature and its contributions to people, as well as the extent to which these valuations are utilised in decision-making (IPBES, 2022a).
- There is limited documentation on how decision-makers make choices and which values they prioritise over others in the decision-making process (IPBES, 2022a).
- There is a lack of understanding of the processes and methods for recognising and incorporating diverse values underpinning the global economic agenda (IPBES, 2022a).

- There is limited information on the adoption of valuation in the private sector, particularly concerning corporate biodiversity impacts, such as the nature risk index parallel to climate risk (Hudson, 2024; IPBES, 2022a).
- There is limited assessment of the policy instruments used for biodiversity conservation on their effectiveness, efficiency, impact and equity outcomes (e.g., environmental education, protected areas, indigenous territories, land acquisitions for conservation, payments for ecosystem services, reducing emissions from deforestation and forest degradation, certification schemes for environmentally friendly production, etc.) (IPBES, 2022a).
- There is also a knowledge gap on the effectiveness, efficiency, and equity outcomes of policy uptake of singular and/or diverse values aimed at balancing nature conservation and agriculture, as well as those recognising indigenous and local knowledge, such as legislation recognising the rights of nature, ecosystems, and rivers (IPBES, 2022a).
- Knowledge gaps also exist in understanding the off-site and long-term social and environmental impacts of protected areas and payments for ecosystem services (Hejnowicz et al., 2014; IPBES, 2022a; Pu et al., 2023).
- There are knowledge gaps in assessing decision outcomes and impacts of the application of specific valuation methods. There is also limited knowledge on how plural valuation and the consideration of diverse values may unlock transformative change (IPBES, 2022a).
- There is limited understanding of how the decline in nature's contributions, including ecosystem services, affects Indigenous peoples and local communities (Brondízio et al., 2021).
- Significant knowledge gaps exist regarding how social factors, such as institutions and norms, influence individuals' and groups' values and behaviours, which are crucial for identifying leverage points for applying diverse values effectively (IPBES, 2022a).
- There is limited understanding of the transformative potential of policy instruments in various contexts as well as the contextual factors that affect the success or failure of policy instruments that consider varying degrees of diverse values (IPBES, 2022a).
- The lack of representation and involvement of stakeholders (such as IPLCs) in valuation and decision-making related to nature have resulted in an unequal distribution of benefits from political, economic, and technological developments, which often prioritise certain values (instrumental) over others. Therefore, there is a lack of knowledge about the relationship between social roles and power structures and their implications on the values that are expressed in decision-making (IPBES, 2022a).
- There is a need of research focusing on governance and institutional conditions necessary for enhancing the effectiveness of, and incentivising, the preservation and restoration of natural landscapes (Barbier, 2022).
- There is also a lack of knowledge on the effects of policy reforms, such as the removal of environmentally harmful subsidies and the use of market-based instruments, on the conservation and restoration of valuable natural habitats and ecosystems (Barbier, 2022; Karolyi & de la Puente, 2023).
- There are gaps in legal knowledge regarding the understanding of values, valuation, and their uptake in policy (IPBES, 2022a).

4.3.4 Effects of biodiversity on its conservation and management, and ecosystem functioning

- There is a need for further understanding of the relationships among taxonomic diversity, functional diversity, and structural diversity to identify mechanisms of biodiversity effects (Hooper et al., 2005).
- The mechanisms by which biodiversity affects ecosystems likely vary across ecosystem properties, types, management goals, and biodiversity change pathways, but this complexity is not fully understood (Hooper et al., 2005).
- There is a knowledge gap in experimental research on stability of the ecosystems. Long-term and field-based experiments are needed to assess temporal stability and responses to disturbances, while also considering factors related to species diversity (Hooper et al., 2005).
- Understanding feedback between biodiversity and ecosystem properties is crucial to integrate experimental findings with broader patterns. There is a gap in linking species extinction and invasion patterns to global change drivers, community structuring forces, and controls on ecosystem properties for effective management and conservation (Hooper et al., 2005).

4.4 Knowledge gaps in biodiversity finance

Research on biodiversity financing is fairly limited. Based on the evolving literature, knowledge gaps in biodiversity finance are of various types ranging from policies and institutions to data and metrics as well as financial risks and costs to financial flows and nature-related financial disclosure. These knowledge gaps are grouped into following five categories.

4.4.1 Policies, regulations, institutions, and their impacts

- National Biodiversity Strategies and Action Plans (NBSAPs) are central for mainstreaming biodiversity by translating global ambition into national policies (Cardona Santos et al., 2023). There is still limited knowledge on the global patterns of how countries have incorporated global ambition into their updated post-2010 National Biodiversity Strategies and Action Plans (NBSAPs) (Whitehorn et al., 2019).
- The effectiveness of negative-screening investment approaches by asset managers and stricter disclosure requirements by regulators on improving corporate environmental risk management is not yet clear.
- There is a knowledge gap regarding whether any improvements in standards will translate into measurable positive impacts on biodiversity (Karolyi & de la Puente, 2023).
- There is limited understanding of the extent to which investment decisions might be influenced by exposure to adverse environmental impacts (Karolyi & de la Puente, 2023)
- Despite the growing attention from institutions including investors, regulators, politicians, corporate leaders, and employees, sustainable finance lacks a clear consensus on its meaning and associated acronyms—ESG (environmental, social, and governance), SRI (socially or sustainably responsible investing), and CSR (corporate social responsibility) (Starks, 2023).
- There is misunderstanding of sustainable finance and related acronyms that complicate the interpretation of investment behaviour and the design of related regulations, requiring further research from a financial economics perspective to provide clearer analyses and interpretations of these issues (Starks, 2023).

4.4.2 Biodiversity-related financial risks and costs

- The existing tools for measuring biodiversity impacts and dependencies, such as data, metrics, and indicators, are limited. There are significant gaps in translating these impacts and dependencies into risks through biodiversity modelling, scenarios, and risk assessment approaches (OECD, 2023).
- Models that analyse the dependence of economic and financial systems on biodiversity and the impacts of these systems on nature and biodiversity are limited (OECD, 2023). While none of the global nature-economy models account for all relevant biophysical or transition policy dynamics, existing multi regional input-output models have limitations. Therefore, there is a need for a more comprehensive, methodologically diversified, and transparent approach to modelling the complex interplay between biophysical and economic systems (NGFS, 2023b).
- There is a lack of studies on the risks associated with biodiversity loss, pricing of these risks, and managing private financial flows (Karolyi & de la Puente, 2023).
- The risk of biodiversity loss to the financial system remains relatively unexplored, as biodiversity-related financial risks are pervasive but poorly understood and largely unpriced (OECD, 2023).
- While there are global cost estimates for biodiversity conservation, it is unclear how these costs would be distributed across the economy or how actions to halt and reverse biodiversity loss would impact economic activity and the financial institutions and their services (Karolyi & de la Puente, 2023).
- There is a lack of integrated approaches combining biodiversity loss and climate change related analysis (OECD, 2023).
- There is a knowledge gap in assessing the cascading risks arising from compounded impacts of biodiversity loss and climate change on financial stability (OECD, 2023).
- Unlike climate change, biodiversity loss lacks clear global mitigation pathways and long-term projections on the physical risks due to the contextual and uncertain nature of tipping points for ecosystems, regions, and biomes and incomplete understanding of interactions.

- This uncertainty coupled with unclear timeframes to consider for assessing biodiversity-related financial risks and a necessity of considering varied modelling assumptions to deal with such uncertainty, complicates risk modelling and limits the ability of model to estimate the economic impact of biodiversity loss. Therefore, there is a need for developing tailored models and scenarios for biodiversity that effectively integrate forward-looking biodiversity scenario analysis and climate considerations (OECD, 2023).

4.4.3 Biodiversity indicators or metrics and measurement approaches or techniques

- One of the important research gaps in biodiversity finance related to measurement lies in the aggregation of its diverse and dynamically changing components – gene, species, and ecosystem. While individual aspects of biodiversity can be assessed, integrating these measures into cohesive and comprehensive indicators that accurately reflect overall biodiversity across time and space remains a significant challenge (Turak et al., 2017).
- Having good metrics is a critical step toward understanding biodiversity risk, risk management, and valuation of biodiversity loss. However, unlike mean sea level rise, global mean temperature rise, and atmospheric carbon dioxide concentrations — which are widely accepted indicators of human impact on the global climate — and given the greater complexity of biological systems compared to physical systems, there are no clear ecological indicators or widely agreed metrics for assessing or quantifying biodiversity as well as nature-related risk and opportunities (Karolyi & de la Puente, 2023).
- The extent to which the lack of standardised metrics to assess and quantify biodiversity impedes further investments in biodiversity remains unclear (Karolyi & de la Puente, 2023).
- While most of the existing metrics and indicators provide adequate information for environmental decision-making, they are insufficient for finance-related purposes. Therefore, further works are needed to effectively translate current biodiversity metrics to better address biodiversity and climate-related financial risks (OECD, 2023).
- Various metrics offer insights into biodiversity processes, and their combined use could provide more granular information, a greater scope of biodiversity and possibly an approach to integrate financial considerations. Further research is needed to assess the viability of multidimensional indices in addressing biodiversity-related financial risk measurement (OECD, 2023).
- Existing biodiversity indices exhibit significant gaps in metrics needed for businesses to implement the KMGBF effectively, particularly in areas such as ecosystem integrity, connectivity and restoration, nature-based solutions, sea use change, aquatic biodiversity, genetic diversity, Indigenous Peoples' knowledge and territories, and urban green and blue spaces, highlighting an urgent need to develop integrated biodiversity indices to accurately measure and disclose their impacts on biodiversity in alignment with the KMGBF (Zhu et al., 2024).
- There is also limited availability and understanding of valuation models for natural capital with potential to rigorously assess the value of natural systems, species, populations, and genetic diversity as well as limited guidance on how to operationalise valuation analysis in terms of returns and factor-based models for the financial sector (Karolyi & de la Puente, 2023).
- While the System of Environmental Economic Accounting (SEEA) is a widely accepted international standard and many countries are advancing SEEA-aligned Natural Capital Accounting (NCA), there is a lack of initiatives focused on how businesses can utilise and benefit from the data collected through these systems (Ingram et al., 2022).
- There is a need of research to address the relevance, frequency, timeliness, and coverage of NCA to enhance their usefulness and value for businesses (Ingram et al., 2022).
- A wide range of tools are in use to assess business impacts on biodiversity, compliance with sustainability standards, dependencies on biodiversity, and offer management guidance, but to effectively integrate these aspects into decision-making as well as ensure coherent and comparable data, there is a need for research on developing harmonised frameworks and standards (Katic et al., 2023; OECD, 2023).
- Although some studies have identified common objectives among different tools, further research is needed to explore challenges on data, metrics, boundaries and baselines, as well as business applications, and identify opportunities for these tools to support the private sector to implement the Kunming-Montreal Global Biodiversity Framework (Katic et al., 2023).
- While landscape-based indicators developed from remote sensing data provide practical proxies for biodiversity assessment, their uniform measures across different regions overlook regional biodiversity variations, potentially leading to unrealistic recovery targets, flawed policies, and erroneous offsetting mechanisms. Therefore, there is a need to develop more advanced tools for business decision-making (Katic et al., 2023).

- Despite the strengths of using empirical spatial data to assess biodiversity conditions within a business or landscape unit, most tools fail to evaluate the spillover effects of business activities on broader ecosystems beyond their immediate boundaries. This gap highlights the need for further research into methods that assess both negative and positive spill-over impacts on surrounding environments or ecosystem functioning at a broader spatial scale (Katic et al., 2023).
- Although existing tools offer significant requirements related to biodiversity conservation, their implementation is only partially aligned with global biodiversity targets. Therefore, there is a need for a unified perspective among stakeholders on measuring, monitoring, and disclosing corporate biodiversity impacts and dependencies to better integrate reliable and comprehensive indicators into corporate reporting and global policy frameworks (Katic et al., 2023).
- The current use of biodiversity assessment tools is limited by the lack of widely accepted biodiversity measurement approaches and a disconnect between policy objectives and the proponents of these tools, highlighting a significant research gap (Katic et al., 2023).
- There is a pressing research gap in exploring how policymakers can effectively promote the strategic implementation of tools in high-priority biodiversity areas through coordinated planning and financial support. Future research is also needed to identify and address capacity gaps within the business sector to effectively mobilise their efforts towards sustained biodiversity-positive outcomes (Katic et al., 2023).
- Current modelling approaches fail to account for biodiversity loss related feedback loops and supply chain relationships within and between the financial sector and the real economy, particularly in response to biodiversity loss. These nonlinear, dynamic interactions are challenging to model and their exclusion may lead to an underestimation of the true impacts of biodiversity loss on both the economy and the financial sector. Further research is needed to address this gap (OECD, 2023).
- While valuing and protecting biodiversity may have notable benefits to climate as carbon mitigation initiatives, there is a limited knowledge of biodiversity's role in carbon cycling (Berzaghi et al., 2022).

4.4.4 Financing options or mechanisms, finance flows, their impacts and scaling pathways

- The Biodiversity Finance Initiative (BIOFIN), managed by the United Nations Development Programme, supports the implementation of NBSAPs and the development of biodiversity finance plans in countries to help close the finance gap. However, the biodiversity-related expenditure data available to develop finance plans are heavily weighted towards public sector, with limited availability of data from private and civil society from other sectors, indicating data gaps to understand biodiversity expenditure patterns.
- There is a lack of data on biodiversity related financial flows or expenditure from private, civil society, and finance sectors (CBD, 2024).
- There is a lack of concerted effort to compile a database of financial transactions in biodiversity finance. Similarly, there is a lack of information on performance and impact of biodiversity finance (Karolyi & de la Puente, 2023).
- There is a need for further scientific research to enhance understanding and analysis of existing private and finance sector instruments for financing nature (Seidl et al., 2024).
- There is a need for research to identify effective strategies for enhancing private sector contributions to financing nature, including the development of appropriate regulatory environments, smart incentives, and market structures to stimulate financial flows into nature finance (Seidl et al., 2024).
- Further research and the development of databases are needed to establish stronger connections between biodiversity investments and their outcomes, including cost guidelines, successful finance solutions, and measures of their effectiveness (Seidl et al., 2024).
- A significant knowledge gap exists in the analysis of biodiversity-related budgetary actions, legal frameworks, and administrative structures across different countries, warranting further research in these areas (Da Silva, 2023).
- There is a limited understanding on how diverse biodiversity finance types such as public, private, philanthropic, blended or hybrid, including their interactions work together to address the biodiversity crisis (Beer, 2023).

- There is a knowledge gap to trace the biodiversity-related financial flows from government bodies, markets, local communities, and emerging actors, identify their effectiveness in bridging the conservation funding gap, build optimise and synergise different financial mechanisms, such as Payments for Ecosystem Services (PES) and Reducing Emissions from Deforestation and Forest Degradation (REDD+) projects, and assess their long-term results and socio-economic impacts for various categories of beneficiaries (Cosma et al., 2023).
- There is a knowledge gap in understanding the effectiveness of two types of international aid that link biodiversity conservation and development goals: *mixed aid*, which integrates biodiversity conservation with development objectives, and *strict aid*, which is focused solely on conservation without a development component. Future research is needed to compare the effectiveness of these approaches and determine the conditions under which each type more effectively achieves conservation goals (Miller, 2014).
- Biodiversity finance is limited and heavily relied on government budgets and philanthropic grants. There is a need of research to develop financial mechanisms that can engage more investors, generate more revenue, and integrate economic incentives with revenue, as well as increases stakeholders' collaboration (Bos et al., 2015).
- There is a need for research to evaluate ecological, cultural, social equity, economic impacts of financial mechanisms, including the necessary legal and cost structures, to ensure their effectiveness (Bos et al., 2015).
- Knowledge gaps such as the absence of standardised data and reporting frameworks, unclear transition pathways for the private sector, insufficient pipelines of investable projects with competitive risk-return profiles, and a limited understanding of the benefits of ecosystem-based approaches in scaling private investments in nature-based solutions, and constraints related to project scalability and replicability are some of the barriers to scaling of private investments in nature-based solutions (CBD, 2024).
- There is a lack of de-risking studies and pilot projects that would be necessary to secure the finance sector's interest in scaling up investments in nature and ecosystem services (Seidl et al., 2024).
- While expanding public and private financing sources for nature such as biodiversity offsets, payments for ecosystem services, debt-for-nature swaps, green bonds, sustainable supply chains, and international environmental agreements that offer potential to address funding gaps (Figure 4), further research is needed on how to scale up and effectively use these mechanisms to enhance funding for nature conservation in developing countries (Barbier, 2022).
- There is a need of research that examines the collective action and accompanying institutional reforms required to ensure that adequate financing of conservation and restoration occurs in host countries (Barbier, 2022).
- A knowledge gap exists in understanding how financial flows for biodiversity are influenced by economic and political networks, rather than by objectivity. Future research is needed to trace biodiversity financial flows through emerging networks within various government ministries, new South-to-South cooperation, and evolving connections between traditional and new actors (Anyango-van Zwieten, 2021).
- Although finance can play a significant role in helping companies achieve the goal of protecting biodiversity by enhancing the effectiveness and efficiency of existing financing mechanisms and addressing existing financial criticalities, more attention needs to be paid on conservation finance by banking and finance scholars (Cosma et al., 2023).
- While ecosystem service (ES) related evidence and arguments can drive support for biodiversity conservation, there is a lack of knowledge on their impacts on the ground and how ES assessments can be strategically used in conservation finance. Additionally, further research is needed to enhance the application of the Ecosystem Services framework in data-poor settings (Berghöfer et al., 2018).
- The allocation of public conservation funding to financial firms that use these subsidies to generate shareholder returns may promote a highly regressive form of social redistribution. There is a knowledge gap in understanding the ethical implications of using public funding for conservation finance, specifically regarding how financial firms leverage tax breaks, conservation easements, and regulatory markets to generate shareholder returns (Kay, 2018).
- Future research is also needed to examine the compatibility of conservation with 'production activities', such as real estate development, mining, and large-scale timber extraction, as well as the long-term effects of distributing property rights to a single property across various actors and uses (Kay, 2018).

4.4.5 Reporting corporate nature-related impacts, dependencies, and risks

- While numerous standards and frameworks for corporate sustainability reporting are already available, there is limited understanding of whether assessing or reporting nature-related risks necessitates the development of entirely new indicators, or if existing sustainability reporting frameworks could provide sufficient information on these risks (Smith et al., 2024).
- Despite substantial efforts to align various biodiversity disclosure initiatives, most companies have knowledge gaps to understand how these different initiatives relate to each other, the extent of their overlap and differences (Lammerant et al., 2024). There is a need for efforts to harmonise global standards and ensure easy understanding and comparison of results (Seidl et al., 2024).
- Businesses and their supply chains, operations, and products depend on and impact nature, resulting in nature-related risks and opportunities. Despite growing stakeholder expectations, most businesses inadequately measure and report these aspects (Smith et al., 2024).
- While existing sustainability reporting indicators may be adaptable, gaps remain in assessing the financial consequences of nature-related risks and providing comparable information across industries and locations (Smith et al., 2024).
- Further research is needed to develop and test new nature-related dependency indicators, as well as to enable businesses across various sectors to effectively report on their nature-related dependency risks (Smith et al., 2024).

4.5 Australia-specific knowledge gaps in biodiversity economics and finance

- There is a significant knowledge gap in understanding the full economic value and benefits of natural capital to embed it into financial decision-making for diverse stakeholders, such as farmers, landholders, indigenous landowners and managers, tourism operators and businesses (DAWE, 2021b).
- Despite increasing global momentum for sustainable practices in agriculture, forestry, and land use, there is a knowledge gap in understanding the environmental limits for these sectors, the implications of global environmental goals for Australia, and the ways to define and measure sustainability across different sectors, including land use (Climateworks Centre, 2022).
- While the Australian Government's National Environmental Science Program (NESP) provides valuable insights into biodiversity, the state and trend of threatened species and ecosystems, and the actions required to support their recovery, existing studies demonstrate that monitoring of threatened species and communities is mostly inadequate, and that 21–46% of threatened vertebrates, 69% of threatened plants and 70% of threatened ecological communities are not monitored at all. Where monitoring does occur, its quality in terms of national extent and adequacy is generally poor (Cresswell et al., 2021).
- There are still very large gaps in the understanding of the state and trend of the environment, including biodiversity, in Australia (Cresswell et al., 2021).
- The TNFD pilot testing conducted in Australia to assess businesses' preparedness indicates significant gaps in a) specialised expertise — particularly in natural science and geo-spatial data, b) data availability and accessibility across direct operations and supply chains, c) the identification of reliable indicators, methodologies, and assumptions for evaluating nature-related impacts, dependencies, and risks, and d) adapting existing reporting frameworks to meet TNFD disclosure requirements (DCCEEW, 2022b).
- A knowledge gap exists in the effective utilisation of data to integrate nature-related issues into decision-making. For example, despite availability of data, financial institutions such as banks and super funds are struggling in finding and matching different data sources to advance their nature-related efforts (ACF, 2024a).

- Natural Capital Accounting (NCA) helps businesses understand their impacts and dependency on natural capital through consistent, comparable indicators within an accounting framework. Its application in the mining sector highlights the need for concerted effort from all stakeholders — including corporations, governments, and regulatory bodies — to refine methodologies, improve data collection and analysis, and integrate NCA into standard business practices (Maybee et al., 2023).
- Financial institutions increasingly acknowledge nature as a material risk and incorporate it into their sustainability policies. But, only a few of them have implemented targeted strategies to address these risks and opportunities in their portfolios (ACF, 2024a).
- A significant knowledge gap exists in the lack of universal metrics for nature, akin to CO_2 for climate change, and the challenges of measuring nature due to its context-specific nature (ACF, 2024a).
- There is a knowledge gap in the quantification of Australian species and their interactions, as well as in understanding the potential impacts of climate change on biodiversity values both on land and at sea (Morton & Sheppard, 2014).
- There is a considerable knowledge gap in identifying the components of biodiversity in the Great Barrier Reef, Australia and understanding how they contribute to local communities through ecosystem services provision (De Valck & Rolfe, 2019).
- There is a knowledge gap regarding the maturity of biodiversity offset requirements in Australia, which highlights the need for further research on the incorporation of offset requirements and an assessment of their effectiveness in relation to actual offset outcomes (Abdo et al., 2024).
- The benefits of conserving biodiversity and the cumulative effect of ecosystem services outweighs the costs to repair or replace those services (Biodiversity Working Group, 2019). For effective conservation, it is important to quantify the value of all services provided by nature in economic terms by expanding Government's effort in implementing environmental-economic accounting to better organise information and provide clarity on environment-economy interaction.

4.6 WA-specific knowledge gaps in biodiversity economics and finance

- WA is highly biodiverse, but the knowledge about many species and ecosystems and some threats to biodiversity are inadequate (EPA, 2007).
- There is a lack of an agreed-upon approach for valuing biodiversity that avoids double counting (Meney et al., 2023).
- A critical knowledge gap and challenge exists in developing a standardised method for incorporating mineral resources into natural capital accounts, due to significant uncertainties such as data limitations, pricing assumptions, and accounting for changes (Meney et al., 2023).
- There is a critical knowledge gap to integrate natural capital accounts with financial systems, setting mining-specific criteria for materiality assessments, addressing the entire value chain in natural capital assessments, and linking climate-related impacts to natural capital stocks and flows (Meney et al., 2023).
- The complex inter-relationships between different components of ecosystem – plants, animals, microorganisms and the non-living environment – is not well understood (EPA, 2007).
- There is also lack of quantitative evidence demonstrating the changes in biodiversity at the ecosystem level (DEC, 2006).
- Valuation of biodiversity within decision-making frameworks in WA is inadequate, which is further exacerbated by insufficient understanding of biodiversity, along with a lack of capacity to effectively address ongoing threats (EPA, 2007).
- WA has a considerable gap in knowledge regarding subterranean fauna (EPA, 2021) and the marine environment (EPA, 2007). Even in areas with high levels of survey, such as the Pilbara, site-specific information is often sparse or non-existent (EPA, 2021).
- There is a notable knowledge gap in assessing the effectiveness of environmental management actions in WA (EPA, 2007).
- There is still lack of full understanding of the adequacy and the philosophical or ethical, social, and ecological impacts and the outcomes of the offsets (May et al., 2017).

4.7 Stakeholder consultation-based knowledge gaps in biodiversity economics and finance

Stakeholder consultations revealed several key knowledge gaps and research needs that complement those identified through the literature review. A total of 35 organisations and 70 individuals across several sectors were consulted to explore knowledge gaps to mainstream biodiversity in economic and financial decisions. Although our focus was to explore knowledge gaps for Western Australia, the gaps identified are relevant to Australia and beyond.

Understanding biodiversity: Plants and animals are historically viewed as pests if they compete with main economic activities, e.g., farming. It could partly be due to lack of understanding of the important roles played by them, requiring effective communication. What would be the effective ways to communicate the importance of plants and animals to change this narrative in some sectors? For this, pilot projects that quantify the contributions of plants and animals (biodiversity) to dominant economic activities are needed.

Measuring biodiversity: Lack of fit-for-purpose type of biodiversity measurement or assessment methods is commonly referred as a major knowledge gap. In addition, information on cost effective, robust, and credible measurement approaches is scarce, either yet to be developed or scaled-up. What would be the unit of measure? How do we measure interactions among different components of biodiversity – what could be a proxy measure for this?

Valuing biodiversity: Quantifying the contribution of biodiversity to outputs or benefits to people is a major gap. In addition, demonstration sites or examples of this connection between different forms of biodiversity to a measure of output or outcome in different context (scale, land use type etc) are not available. Even the information available on value of biodiversity do not provide the mechanism to generate that value (actionable road map). Actionable road map to generate value in different contexts (farming, natural resource management, mining operations etc) are noticeable gaps. How do we measure the residual gap in terms of economic and social values in applying mitigation hierarchy (avoid, minimise, restore, and compensate)?

Data, models, and frameworks: Fit-for-purpose data on biodiversity (impact, dependency, opportunity, and risks), models to capture complexity of biodiversity (ecosystem functions and processes), and widely applicable frameworks for sustainability reporting are not available for decision-makers at various levels (operation, strategic, project, portfolio etc.) within and across businesses and government agencies, i.e. private and public sectors.

Biodiversity market – demand and supply: Given nature positive plan and related regulatory provisions or measures that aim for nature positive future:

- What does 'good' look like for a biodiversity market (voluntary or compliance)?
- Who are the market participants (buyers and sellers)?
- What level of detailed information is available on demand and supply sides of biodiversity market, particularly on the demand side – type, volume, and price of biodiversity credit or certificate?
- There is a knowledge gap on biodiversity market design and incentive structures for different contexts and different components of biodiversity (i.e. biodiversity exchange rate)?
- What are demand and supply side inhibitors for a matured and functioning market?
- What enabling conditions are needed or in place, and how to provide policy certainty to market participants such as landholders, companies, and investors etc.?

Biodiversity finance: Given the financing need for biodiversity conservation, increasing financial flows from private sector to finance biodiversity is essential. Would the voluntary approach to create additional finance be sufficient or likely to work in the long term? What are the carrots and sticks in the policy basket for this? How effective are these incentives and dis-incentives? These are some of the finance related questions that appeared during stakeholder consultations. In addition, what would be the role of blended finance, how would it be structured with fit-for-purpose in mind? Some additional questions include:

- How could we make biodiversity an investible good at scale, as investment in biodiversity competes with many other options that investors have?
- What are the available financial products targeted for biodiversity or nature conservation in different contexts? What are their key features?
- How effective are the financial products targeted for biodiversity conservation and nature positive outcomes?
- What are the effective ways to de-risk biodiversity-focused investments?
- How can governments and regulators help the private sector to encourage biodiversity-focused investments while maintaining reasonable rates of return from businesses?
- What mechanisms or instruments are in place to increase financial flows to enhance biodiversity or nature from financial institutions, investors, and private sectors?

5. Background

5.1 General overview of biodiversity values and conservation initiatives

Nature is often viewed through the lens of biodiversity, ecosystems, evolution, the biosphere, humankind's shared evolutionary heritage, and biocultural diversity from a western science perspective. Other knowledge systems, however, view nature from a holistic and relational concept such as Mother Earth and systems of life. For many sociocultural groups, including Indigenous Peoples and Local Communities (IPLCs), humans and nature are inseparable, with a context-specific understanding of their symbolic, spiritual, and physical interconnectedness (IPBES, 2022a).

In general, people perceive, experience and interact with nature in many ways, leading to a broad spectrum of values associated with it (IPBES, 2022a). The term 'value' encompasses diverse ideas related to goals, principles, priorities, and importance levels, making it difficult to define nature's values universally across cultures and academic traditions. IPBES synthesises multiple theoretical perspectives to categorise values typologies into worldviews (*e.g., Anthropocentric, bio/ecocentric, Pluricentric, Cosmocentric world-views*), knowledge systems (*e.g., Scientific knowledge systems and Indigenous and local knowledge systems*), broad values (*e.g., freedom, justice, responsibility, harmony with nature, harmony with Mother Earth, health, prosperity*), specific values (*e.g., instrumental, intrinsic and relational values*), and value indicators (*e.g., biophysical, monetary and sociocultural measures*) (IPBES, 2022a). The diverse values individuals ascribe to nature, its contributions to human wellbeing, and their relationship to quality of life affect people's attitudes toward nature. Understanding the value that people place on nature is vital, as it, in turn, shapes the policies, norms, and technologies that govern human-nature interactions (IPBES, 2022a).

The valuation of nature is a deliberate process aimed at generating information about the values of nature and human-nature relationships, while a valuation method is a procedure used to elicit and articulate these values (IPBES, 2022a). There is a broad range of such methods and approaches emerging from diverse disciplinary fields and traditions. Despite over 50 valuation methods from various disciplines globally assessing the values that individuals or communities hold about nature, nature's contributions to people, and human-nature relationships, the integration of diverse values of nature into policies and policy instruments are still limited (IPBES, 2022a). Identifying knowledge gaps that limit the recognition of diverse value of nature is crucial for their effective integration into policy decisions and achieving better biodiversity and human wellbeing outcomes (IPBES, 2022a).

Biodiversity is declining faster than ever in human history, and nature and its vital contributions to people are deteriorating globally due to multiple human-driven factors, including changes in land and sea use; direct exploitation of organisms; climate change; pollution; and invasion of alien species (IPBES, 2019). Numerous studies reveal an alarming degradation of nature and biodiversity decline. For instance, according to The Millennium Ecosystem Assessment, 15 of the 24 ecosystem services that were assessed are either being degraded or used unsustainably (MEA, 2005). According to The Economics of Ecosystems and Biodiversity (TEEB), the economic value of biodiversity or the cost of biodiversity loss to human society is huge, and therefore biodiversity needs to be mainstreamed in decision-making. For example, estimated annual investment of US$45 billion into protected areas alone can deliver ecosystem services worth of US$5 trillion per year (TEEB, 2010). Similarly, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) revealed declines in 14 of 18 categories of nature's goods and services since 1970, with around one million plant and animal species already facing extinction and the global species extinction rate being tens to hundreds of times higher than average over the past 10 million years (IPBES, 2019). The average abundance of most terrestrial species has fallen by at least 20%, amphibians by 40%, reef forming corals and marine mammals by 33% (Pelle et al., 2022).

Ecosystems worldwide are deteriorating, with global indicators of healthy ecosystem extent and condition suggesting a 47% reduction (Pelle et al., 2022). WWF's Living Planet Report showed an average decline of 69% in wildlife populations since 1970 (WWF, 2022). A World Economic Forum report on global risks in 2024 ranked biodiversity loss and ecosystem collapse as the third most significant global risk humanity will face over the next decade (WEF, 2024). The World Bank (2021) warned that the collapse of ecosystem services, such as wild pollination and the provision of food and timber can cause a loss of 2.3% of global GDP (US$2.7 trillion) annually by 2030, with poorer countries being hardest hit by such impacts. Environmental degradation can push an ecosystem to a tipping point, beyond which it may transition to a new state or collapse completely (World Bank, 2021). A study on safe and just 'earth system boundaries' by Rockstrom et al. (2023) showed that seven out of eight such boundaries have been

exceeded due to human activities and pressures. The Dasgupta Review on the Economics of Biodiversity emphasises that humans have degraded the nature or biosphere to the extent that the demand for its goods and services far surpasses its ability to provide them sustainably (i.e., demand to supply ratio is 1.7 to 1) (Dasgupta, 2021).

Nature or biodiversity loss is associated with the lack of our full understanding of interconnections (impacts and dependencies) economic activities and nature, and also between stocks and flows of natural capital. Such understanding would help us to make informed decisions. However, we are facing challenges such as how to operationalise what we know about the value of nature or biodiversity into day-to-day decisions (policy, economic and financial), at different levels (program implementation to policy making) across sectors by different actors (private corporations, public agencies, and community organisations)? Context-specific answers to this question is paramount to halt or reverse loss of biodiversity or nature.

The international community or inter-governmental agreements have been vital in addressing the biodiversity decline (Hudson, 2024; Lanzas et al., 2024). The United Nations Convention on Biological Diversity (CBD), signed by 150 government leaders at the 1992 Rio Earth Summit, was one of the first to recognise biodiversity as a global asset (CBD, 1992). Since then, there has been significant governmental and regulatory activities to protect and preserve biodiversity (Figure 6). In 2010, The UN declared the 2011–2020 period as the 'Decade on Biodiversity', and the CBD held in Aichi Prefecture, Japan outlined a Strategic Plan and 20 targets on biodiversity (the Aichi Biodiversity Targets) to be met by 2020 (CBD, 2010). In 2015, The UN committed to halt biodiversity loss as one of its Sustainable Development Goals (UN, 2015). Despite notable progress on certain Aichi Targets, none were fully met by 2020 (CBD Secretariat, 2020). Various studies have attributed the failure to the setting of the Aichi Targets itself, weak National Biodiversity Strategies and Action Plans (NBSAPs), insufficient financial resources and imperfect indicators (Xu et al., 2021). Consequently, the decline in biodiversity has still persisted as a significant global issue (Hudson, 2024), undermining the attainment of the Sustainable Development Goals (CBD Secretariat, 2020).

Without transformative change, nature's decline will persist through 2050 and beyond due to the projected impacts of increasing land and sea-use change, exploitation of organisms and climate change (IPBES, 2019). Transformative change to halt and reverse this trend will require a new economic paradigm beyond GDP growth and restructuring of educational and financial systems, among others (Dasgupta, 2021), emphasising production and consumption patterns that operate within planetary boundaries and promote net gains in biodiversity and planetary health, including integration of traditional and innovative conservation methods, and implementation of proactive, precautionary, inclusionary, and target-based environmental laws that support these efforts (Leclere et al., 2020; Pelle et al., 2022).

In capturing the value of ecosystems and environment-economy interactions in national accounts, UN has endorsed the System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA EA) in 2021 as a globally agreed natural capital accounting framework (UN et al., 2021). It focuses on ecosystem asset and measures stock and flow in both physical (extent, condition, and service flow accounts) and monetary (service flow and asset accounts) terms (UN et al., 2021).

In December 2022, the 15th Conference of Parties (COP15) to the UN CBD adopted the Kunming-Montreal Global Biodiversity Framework (CBD, 2022) to halt and reverse global biodiversity loss by addressing the multifaceted drivers behind biodiversity declines around the planet (Hughes, 2023). The KMGBF includes 4 goals related to the 2050 Vision of a 'world living in harmony with nature', supported by 23 targets to be achieved by 2030, all aimed at enabling just transitions toward nature-positive societies (i.e., reversing nature loss to achieve a net positive improvement in nature by 2030, with more biodiversity and nature than today, followed by a full recovery by 2050, with large-scale restoration of nature) (CBD, 2022; Kok et al., 2022).

In parallel to UN led initiatives, other government and private sector led initiatives are also rapidly evolving to mainstream biodiversity. Some examples of such government-led initiatives include Nature Positive Plan (2022) of the Australian government, 10% Biodiversity Net Gain policy of the UK government (2024), Restoration Law (2024) and Deforestation Regulation (2024) of the European Union.

Private sector has also initiated sustainability initiatives and developed reporting standards for nature or biodiversity. In 2023, Taskforce on Nature-related Financial Disclosure (TNFD) has published general disclosure recommendations and first set of sector guidance on nature-related impact, dependency, risks, and opportunities for businesses using a LEAP (locate, evaluate, assess, and prepare) approach (TNFD, 2023). In the same year, International Sustainability Standard Board (ISSB) published its standards on general sustainability- related disclosures (IFRS S1), and currently working on a project to research disclosure on risks and opportunities associated with biodiversity, ecosystem, and ecosystem services. In Europe, Corporate Sustainability Reporting Directive (CSRD) came into force in 2023, which follows a disclosure process outlined by European Sustainability Reporting Standards (ESRS) adopted by the European Union. Of the 12 ESRS

Standards, E4 covers the disclosure requirements for Biodiversity and Ecosystems (CSRD ESRS E4) (EFRAG, 2023). Global Sustainability Standards Board (GSSB) issued Global Reporting Initiative (GRI) topic standards for impact reporting on biodiversity GRI 101: Biodiversity 2024, which is the updated version of its earlier biodiversity standards – GRI 304 – released in 2016 to align with TNFD recommendations (GRI, 2024). ISSB is also planning to align its biodiversity and ecosystem related standards with TNFD recommendations. Similarly, other sustainability standard developing bodies are currently actively working on this area.

As indicated in introductory section, Figure 5 presents the links between state of biodiversity, ecosystem services, economic activities, drivers or pressures, risks, disclosures, and nature positive economy. Figure 6 presents timelines of the major events, initiatives, reports, and milestones in mainstreaming biodiversity into decision-making, including economic, finance, and reporting initiatives.

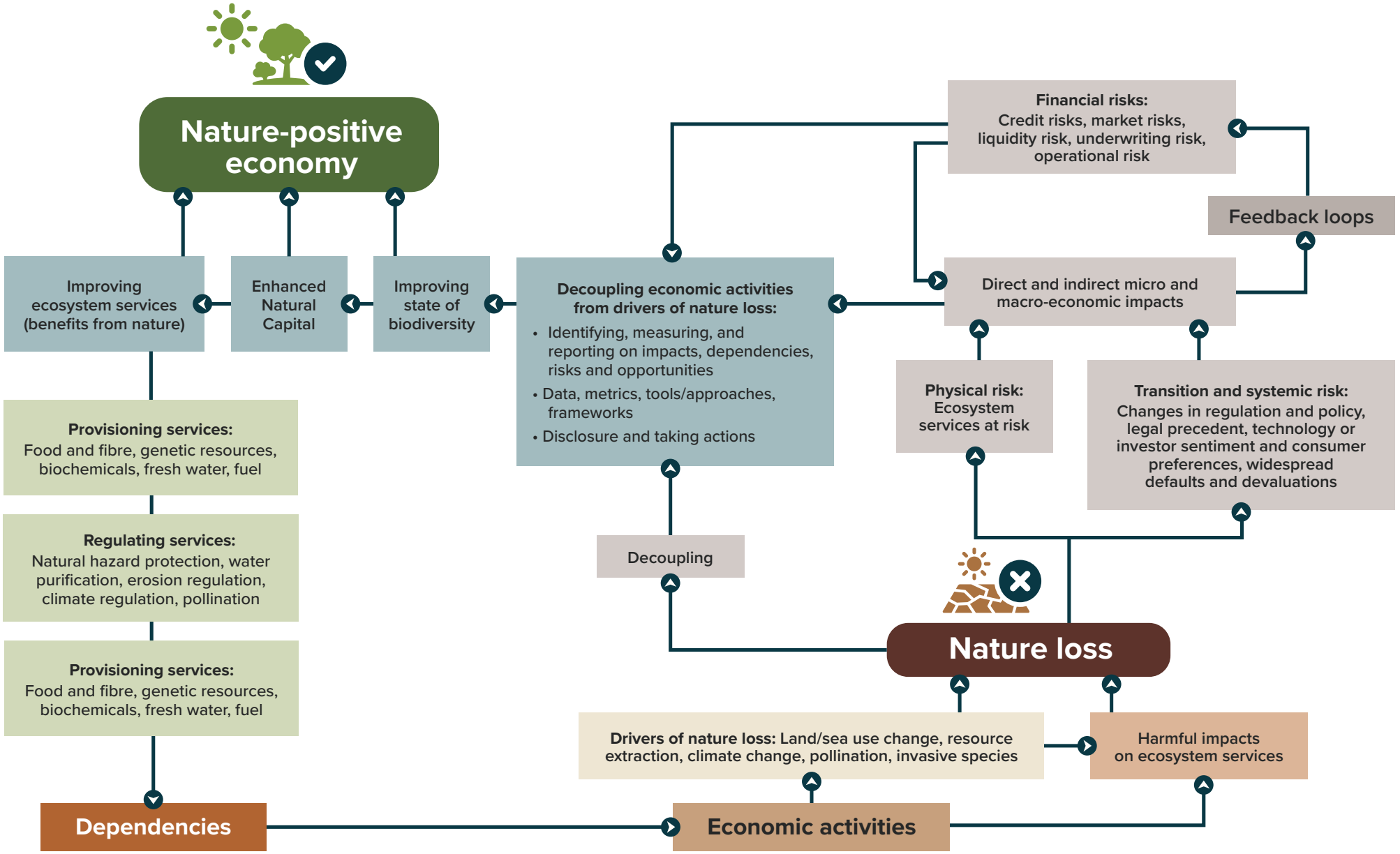

Figure 5. The links between state of biodiversity, ecosystem services, economic activities, drivers, risks, disclosures, and nature positive economy

Source: adapted from ACSI, 2021; CICL, 2021; OECD, 2010, 2023; UNEP-WCMC et al., 2022; WEF & Wyman, 2024

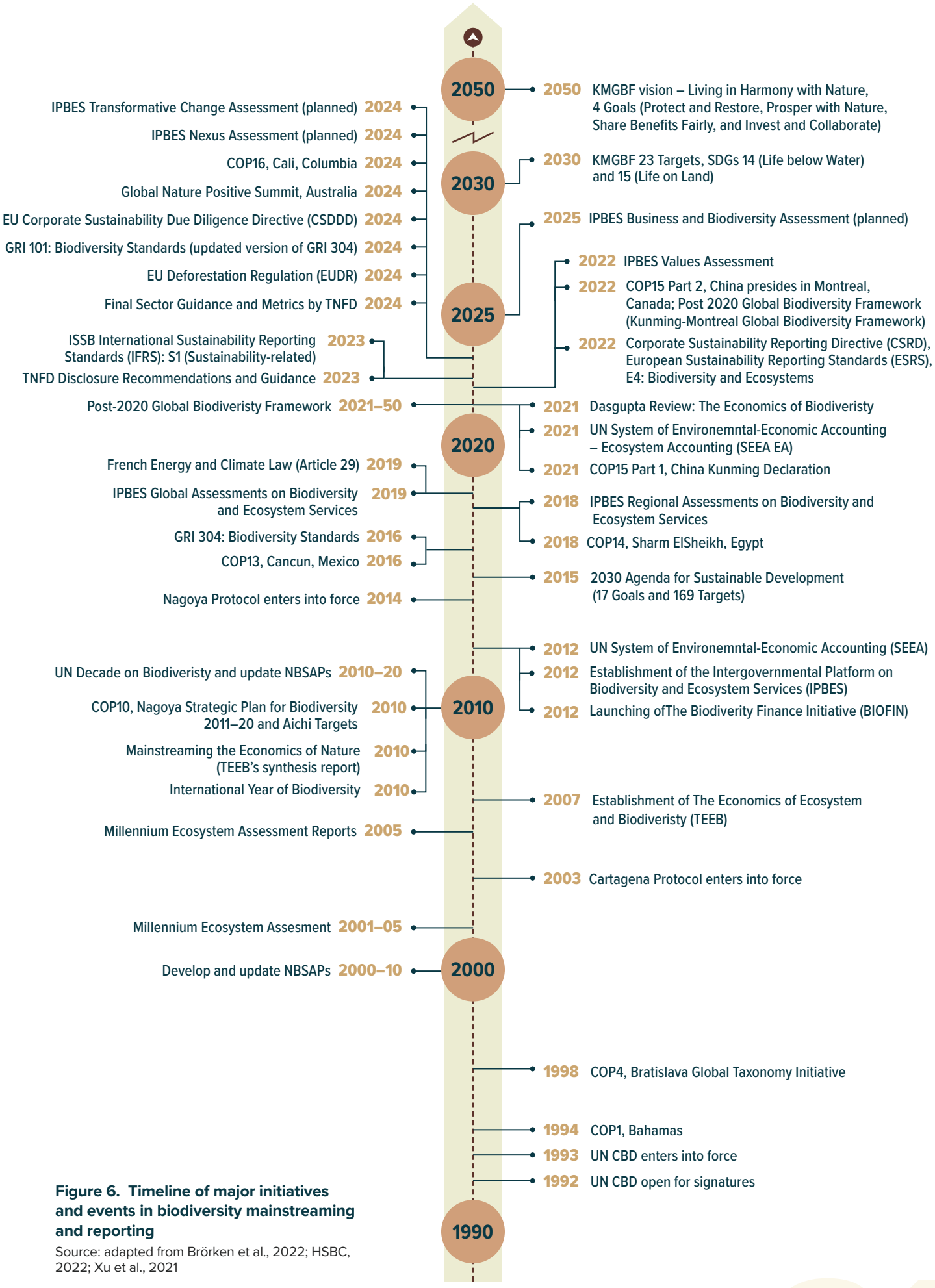

Figure 6. Timeline of major initiatives and events in biodiversity mainstreaming and reporting

Source: adapted from Brörken et al., 2022; HSBC, 2022; Xu et al., 2021

5.2 Brief overview of state of biodiversity and associated policy development

5.2.1 Australia

Australia is one of the 17 megadiverse countries in the world, which covers less than 10% of the Earth's surface (Barraclough et al., 2023; Biodiversity Working Group, 2019). It uniquely contributes to global biodiversity by supporting over 8% of all the world's species (Myers et al., 2000) but substantially higher proportion of globally endemic species. Australia, its island territories, and surrounding ocean support 600,000 to 700,000 native species; many of these are endemic (93% of flowering plants, >80% of invertebrates, 87% of mammals, 93% of reptiles, 94% of frogs, 74% of freshwater fishes and >50% of temperate marine fishes) (Cresswell et al., 2021; Dielenberg et al., 2024; Myers et al., 2000). Australia's rich biological diversity is the result of extended geographic isolation following its separation from the Gondwanan supercontinent 30 million years ago (Joseph et al., 2014), coupled with a unique blend of low-nutrient soils, a highly variable climate, and a long history of widespread fire (Legge et al., 2023).

Australia is one of the most resource- and carbon-intensive OECD economies, with significant concerns about biodiversity and water resources (OECD, 2019). Australia is a leading producer of 27 minerals, with 15 ranking in the top 5 globally. The country is the world's leader in economic resources for gold, iron ore, lead, nickel, rutile, uranium, zinc, and zircon (Hughes et al., 2024). Australia's mining sector contributes to around 13.4% of its Gross Domestic Product (GDP) (Department of Industry Science and Resources, 2024). Every sector of the Australian economy, including mining, relies both directly and indirectly on nature to varying extents, with this reliance stemming from different ecosystem services derived from various elements of natural capital across their value chains (Pelle et al., 2022). Approximately half of Australia's GDP (49.3% or AU$892.8 billion) has a moderate to very high direct dependence on ecosystem services (Pelle et al., 2022). Sectors with a very high direct dependence on nature include agriculture, forestry, and fisheries (AU$38.7 billion), food manufacturing (AU$23.1 billion), construction (AU$144.4 billion), and waste and water services (AU$19.2 billion), which contribute AU$293.6 billion (16.1% of Australia's Gross Value Added) annually to the economy (about 15.9% of GDP) (Pelle et al., 2022). Sectors with a moderate to high direct dependency on nature include mining (AU$127.0 billion), real estate (AU$207.0 billion), transport and logistics (AU$89.6 billion), and accommodation and hospitality (AU$44.3 billion), that contribute AU$602.7 billion to Australia's economy (approximately 33% of GDP) (Pelle et al., 2022).

Australia's exports are dominated by sectors with the highest nature dependency, in particular mining, manufacturing, and agriculture (Pelle et al., 2022). Among the states in Australia, Western Australia, the leading producer of iron ore, LNG, and a significant producer of wheat and other agricultural products, is Australia's most nature-dependent state, with 66.9% of its Gross Value Added (AU$183.8 billion) having moderate to very high direct reliance on nature, followed by The Northern Territory (55% or AU$13 billion), Queensland (53.8% or AU$187.1 billion), and Tasmania (50.6% or AU$15.3 billion) (Pelle et al., 2022).

Natural capital is vital to Australia's economy and national wealth. The value of its natural capital is estimated to be AU$6.4 trillion in 2016-17 (Australian Bureau of Statistics, 2018), and is also central to indigenous culture. Over millennia, Indigenous peoples have developed a close and unique bond with the lands and environments in which they live, and established distinct systems of knowledge, innovation and practices relating to the use and management of biodiversity (ACSI, 2021). However, Australia's rich biodiversity has been rapidly declining for over 200 years since the beginning of European colonisation, which involved displacing Indigenous peoples from the land who had managed it for more than 60,000 years (Dielenberg et al., 2024; Legge et al., 2023). Australia is on the top of the lists in both nature destruction and mammal extinctions and ranks second worldwide for overall biodiversity loss (ACF, 2022; Biodiversity Council, 2023). Australia is the only developed country on the list of global deforestation hotspots and ranks third worldwide for the total number of extinct and threatened animals, and 8thh for extinct and threatened species (ACF, 2022).

Since 1788, 100 Australian species (including one protist, 38 vascular plants, 10 invertebrates, one fish, four frogs, three reptiles, nine birds, and 34 mammals) have become extinct or extinct in the wild (Cresswell et al., 2021; Woinarski et al., 2019). The extinction of 34 mammal species, accounting for approximately 10% of Australia's terrestrial mammal fauna at the time of colonisation, is the highest of any country in the past two centuries (Cresswell et al., 2021; Legge et al., 2023). Losses of previously abundant and widespread species have also occurred across a wide range of environments in Australia (Legge et al., 2023).

The actual number of extinctions is likely to be much higher, as many species are either poorly surveyed, poorly described, or both (Cresswell et al., 2021). Additionally, more than 2,100 Australian species and more than 100 ecological communities are currently recognised as threatened or at risk of extinction (Biodiversity Council, 2023). In 2021, more species were classified as threatened or elevated to higher threat categories (e.g., from Vulnerable to Endangered to Critically Endangered) compared to five years ago, marking an 8% increase since 2016 (Cresswell et al., 2021). The most significant increases in the number of threatened species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) were observed in invertebrates and frogs, which rose by 22% and 21% respectively, while reptiles and birds saw the smallest increase, approximately 5% (Cresswell et al., 2021). Numerous other species and ecosystems are facing significant ongoing losses, with many likely going unnoticed (Legge et al., 2023) .

Ecosystem disruption and degradation can result in their collapse (Cresswell et al., 2021), and cause irreversible changes to structure, composition, and function — and endanger biodiversity, human health, and wellbeing (Bergstrom et al., 2021). However, an analysis of 19 Australian ecosystems, spanning both terrestrial and marine environments and covering around 1.5% of the Earth's surface (over 7.7 million km^2), from northern Australia to coastal Antarctica, including deserts, mountains, rainforests, freshwater, and marine biomes, has shown signs of collapse or near collapse in all studied ecosystems (Bergstrom et al., 2021). A national-scale assessment revealed that Australia has exceeded limits for 3 of the 5 planetary boundaries — biodiversity, land-system change, and nitrogen and phosphorus flows — while also approaching its national limits for climate change and freshwater use (Climateworks Centre, 2022). Intense competition for land and water resources in Australia has led to ongoing declines in both the quantity and quality of land- and water-based natural capital—such as native vegetation, soil, wetlands, rivers, and biodiversity, affecting the provision of essential ecosystem services (Cresswell et al., 2021).

Australia's biodiversity decline and transformation of its environments have mainly been driven by a range of threats, including habitat destruction and fragmentation due to land clearing for agriculture and urbanisation; the introduction of invasive plants, animals, and diseases; the disruption of First Peoples' practices in caring for Country, including fire management; and the extraction of water including the modification and regulation of fresh-water ecosystems (Dielenberg et al., 2024; Legge et al., 2023). These impacts are now compounded by climate change, particularly through extreme drought, heat, wildfire, and flooding (Dielenberg et al., 2024; Legge et al., 2023). A World Wildlife Fund report projected that, under a business-as-usual scenario, nature loss could cost the Australian economy US$20 billion annually by 2050, ranking Australia as the fifth worst-affected country in terms of potential GDP loss (Roxburgh et al., 2020).

Despite Australia being a signatory to the United Nations CBD and having environmental legislation such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), supported by national, state and local biodiversity conservation frameworks for over 20 years, biodiversity in Australia continues to be depleted at alarming rates (ACF, 2024b; DAWE, 2020). Similarly, despite the Australian Government's release of the Environmental Offsets Policy, 2012 under the EPBC Act (which defines offsets as measures that compensate for the residual adverse impacts of an action on the environment) (DSEWPC, 2012), a recent study reveals that over two-thirds of 218 offset sites approved between 2008 and 2012 lack legal obligations for adequate protection, with about half poorly protected, 21% unprotected, and fewer than 25% in Queensland and Western Australia adequately protected, highlighting a significant failure in the national offsetting regime to adequately protect offset sites (ACF, 2024b). Additionally, Abdo et al. (2024) revealed that offset approvals in Australia lacked transparency and were not consistently maturing in terms of increasing transparency or ensuring improved environmental outcomes. The increasing threats to Australian biodiversity reflect a low value placed on environmental conservation and a greater focus on other values at the expense of the environment, as well as weaknesses or failures in its environmental legislation, policy, and management to effectively conserve biodiversity, control threats, or allocate sufficient funding for conservation. The domestic government expenditure on biodiversity and associated administrative functions remains at AU$400–500 million annually over the last decade (ACSI, 2021; CBD, 2019; Legge et al., 2023). The 'Blueprint to Repair Australia's Landscapes' report suggests an urgent investment need of AU$7.3 billion (i.e., 0.3% of GDP) per year (in 2020$) for 30 years to repair last two centuries of degradations that took place in Australia (WGCS, 2024).

Despite its significance, natural capital remains undervalued and neglected in financial and business decisions (DCCEEW, 2022b). Addressing ongoing species loss and widespread ecosystem degradation, along with their impact on economies, life, culture, and future, requires a fundamental shift in how we value and interact with the environment, including developing stronger environmental legislation, implementing effective policies, expanding institutional and human capacities, and substantially increasing investment from both public and private sectors (Legge et al., 2023).

The recent review of the EPBC Act (Samuel Review) and the 2021 State of the Environment Report both emphasise that Australia's current environmental law is outdated and ineffective in halting or reversing the ongoing decline of its environment and heritage, and therefore requires fundamental reform (DCCEEW, 2022a; Samuel, 2020). To address this, the Australian Government released the 'Nature Positive Plan' in 2022 which commits to law reforms in 3 stages and is intended to be 'the most comprehensive remaking of national environmental law since the EPBC Act was introduced' (Biodiversity Council, 2023; DCCEEW, 2022a). The first stage of EPBC Act reform has been completed in late 2023, with the endorsement of the '*Nature Repair Act 2023*' and expanding the water trigger for assessment of coal and unconventional gas developments (DCCEEW, 2022a, 2024a). Stage two of the EPBC Act reform has recently been introduced in Parliament, with the Nature Positive Bills 2024 tabled to establish Environment Protection Australia (EPA), an independent national environmental protection agency with expanded compliance and enforcement powers, and Environment Information Australia (EIA), a new body responsible for managing national environmental data and reporting (DCCEEW, 2024a; McCredie et al., 2024). Stage 3 is expected to overhaul the entire EPBC Act and complete the environmental law reforms outlined in the Nature Positive Plan (DCCEEW, 2024a; Medlock, 2024). These reforms emphasise the concept of nature positive to align with the KMGBF, focusing on enhancing the diversity, abundance, resilience, and integrity of species, populations, and ecosystems to halt and reverse nature loss by 2030, with full recovery targeted by 2050, measured against a 2020 baseline (EDO, 2024).

The Australian Government has established bilateral agreements with every state and territory which allow states and territories to assess projects involving matters of national environmental significance under the EPBC Act, with the Commonwealth Environment Minister relying on their reports to make approval decisions (DCCEEW, 2024b). It is also working with all states and territories to update Australia's Strategy for Nature 2019–2030, launched in 2019 by the Commonwealth, all state and territory governments and the Australian Local Government Association (ALGA), to achieve a shared roadmap for 'better understanding, caring for, and sustainably managing nature by 2030' and contributing to the goals of the KMGBF (ACSI, 2021; DCCEEW, 2024d). Additionally, it recently released the Threatened Species Strategy 2021–2031, which aims to provide a framework for protecting and recovering Australia's threatened species through eight action areas, including habitat conservation and restoration, climate change adaptation, effective conservation planning, and improving knowledge and tools (DAWE, 2021a).

Since 1995, Australia has been producing a national State of Environment report every five years, which examines every aspect of Australia's environment and heritage, including rivers, oceans, air, ice, land, and urban areas (Cresswell et al., 2021). Mandated by the EPBC Act, it is an independent, comprehensive and evidence-based assessment of the state of Australia's environment (CSIRO, 2022; DCCEEW, 2024c). The Australian Bureau of Statistics (ABS) and DCCEEW are currently working on measuring and valuing Australia's ecosystems in compiling ecosystem accounts. ABS is planning to release first comprehensive set of National Ecosystem Accounts for Australia in 2025 (Australian Bureau of Statistics, 2024, September 17).

Additionally, the Australian Government has partnered with industry, through the Australian Sustainable Finance Institute (ASFI) to develop an Australian sustainable finance taxonomy and mobilise private capital for sustainable activities, address greenwashing, and support Australia's transition to net zero (The Australian Government the Treasury, 2024). The ASFI launched the Sustainable Finance Roadmap in 2020, outlining a plan to align Australia's financial system with a sustainable, resilient, and prosperous future for all Australians (ASFI, 2020). The Treasury of the Australian Government also released the Sustainable Finance Roadmap in 2024. In 2023, The Treasury and the Australian Office of Financial Management of the Australian Government released the Australian Government Green Bond Framework, which details how the Australian Government will issue green bonds, including the criteria for identifying, selecting, managing, and reporting on related expenditures, while outlining its key climate and environmental priorities (The Treasury & Australian Office of Financial Management, 2023). In December 2023, the Australian Government also established the Nature Finance Council to advise the Minister for the Environment and Water on strategies to mobilise the capital needed for a nature positive economy and increase private sector financial investments that benefit nature (The Australian Government the Treasury, 2024). In August 2024, the Australian Government established an independent Nature Repair Committee to support the integrity of the nature repair market and to provide advice to the Minister on development, prioritisation and review of methods and biodiversity assessment instruments.

Table 3. Regulatory instruments of Commonwealth Government to conserve and manage biodiversity

Year	Regulatory instrument (plan, policy, act, guideline, and report)
1997	Indigenous Protected Areas (IPA) program 1997
1999	Environmental Protection and Biodiversity Conservation Act
2009	First Independent Review of EPBC Act (the Hawke Review)
2012	EPBC Act Environmental Offset Policy
2021	Second Independent Review of the EPBC Act (the Samuel Review)
2021	Threatened Species Strategy 2021–2031
2021	State of the Environment Report
2022	Nature Positive Plan
2023	Nature Repair Act (established the Nature Repair Market)
2023	Nature Repair (Consequential Amendments) Act
2023	Nature Finance Council (Chair Ken Henry)
2023	Sustainable Finance Strategy Consultation Paper
2023	Australian Government Green Bond Framework
2024	Sustainable Finance Roadmap (Treasury/Council of Financial Regulators)
2024	Nature Repair Committee (Chair Steve McCutcheon)
2024	Net Zero Plan
2024	Australian Sustainability Reporting Standards
2024	AASB Australian Sustainability Reporting Standards
2024	Nature Positive (Environment Information Australia) Bill
2024	The Global Nature Positive Summit
2024	Australian Sustainable Finance Taxonomy
2024	Treasury Laws Amendments (Financial Market Infrastructure and Other Measures) Act
2024	Future Made in Australia Bill

Australia has been a member of the Taskforce on Nature-related Financial Disclosures (TNFD) Stewardship Council since November 2021 and supported the design and development TNFD (DCCEEW, 2022b). TNFD is an international, private sector or market-led initiative aiming to support organisations to identify, report, and effectively manage their nature-related risks and opportunities. TNFD has released its disclosure recommendations and guidance in September 2023, and initiated pilot testing. The TNFD pilot testing with Australian corporations and financial institutions, involving 23 organisations and six peak industry bodies — along with an assessment of biodiversity disclosures from 11 ASX-listed companies across various sectors — reveals that substantial effort is needed to meet the requirements of TNFD framework (ACSI, 2021; DCCEEW, 2022b). The 2024–25 Budget of the Australian Government provided $4.1 million over two years for the Department of Climate Change, Energy, the Environment and Water (DCCEEW) to develop tools and guidance to support the voluntary uptake of nature-related financial reporting by businesses and financial institutions (The Australian Government the Treasury, 2024). The Australian Treasury has indicated that nature-related risk disclosures will ultimately be introduced as part of Australia's new sustainability reporting requirements. However, Australia still lags behind other OECD countries in regulatory progress, requiring more robust advocacy from financial institutions to implement these disclosures and maintain international competitiveness (ACF, 2024b)

5.2.2 Western Australia

Western Australia, the largest state or territory in Australia, occupies approximately 32.9% of nation's land area and 28.2% of its marine area (Geoscience Australia, 2014). However, it has a low population density of approximately 1 person/km^2, primarily due to its extensive desert areas and inhospitable climate across much of the region (Kalliolevo et al., 2021). Nevertheless, WA is not only one of the most biodiverse regions on the continent but is globally unique with some of the highest rates of endemism on the planet (The Wilderness Society WA, 2021). It has eight[7] of Australia's 15 biodiversity hotspots, and the south-western land division of Western Australia (SWWA) is recognised as one of the world's 36 biodiversity hotspots (Bailey et al., 2018; DWER, 2019). WA has approximately 10,842 native vascular plants (Florabase, 2024) among which 8952 are endemic (Gallagher, 2020). In particular, SWWA is renowned for its extraordinary diversity of endemic plants, hosting over 8,000 plant species, and about half of which are found nowhere else (Gioia & Hopper, 2017; Rix et al., 2015). This uniqueness and endemism in biodiversity is the result of Western Australia's vast geographical size, diverse climate, extensive wilderness areas, regions with extremely nutrient-impoverished soils, and the fact that significant areas of the state have neither been submerged by the sea nor glaciated over geological time (WABSI, 2024).

WA is also one of the most productive and diversified mineral and petroleum regions in the world, producing more than 50 mineral and petroleum products commercially worth AU$270 billion in 2022–23. Iron ore is the State's most valuable non-renewable resource, followed by liquefied natural gas (LNG), gold, lithium, crude oil and condensate, alumina and bauxite, nickel, copper, and mineral sands (WATC, 2024). While studies indicate that the mineral industries impact less than 0.05% of Australia's terrestrial land surface and has not been linked to the extinction of any known species, with one possible exception (Lloyd et al., 2002), mining has the potential to impact biodiversity through direct effects such as land clearance, water or air pollution, indirect effects from social or environmental changes, and cumulative effects from interactions with other developments (ICMM, 2006). Mining, agriculture and urban development are important sectors to the State's economy, but all result in a degree of clearing and vegetation degradation (DWER, 2019). Land clearing for mining in Western Australia has expanded rapidly, with limited public awareness and oversight (Auditor General for Western Australia, 2007). By 2023, mining activities had affected 225,935 hectares across WA, with only about 20% of that land undergoing some form of rehabilitation (DMIRS, 2023). The area disturbed by mining companies, surpasses the size of Hong Kong (Barry, 2018). Because WA has the highest direct dependency on nature among Australian states and territories, its economy is also at the greatest risk from environmental degradation (Pelle et al., 2022).

Native vegetation is one of WA's most valuable natural assets (The Wilderness Society WA, 2021). However, WA has already witnessed the clearing of the 18 million hectares of native vegetation, primarily in the SWWA, where up to 93% of the original vegetation has disappeared in some local government areas (DWER, 2019). Additionally, fragmentation, over-grazing, weed invasion, altered hydrology, salinity, diseases, feral animals, and climate change, are also causing severe declines in ecosystem integrity and putting remaining native vegetation at high risk (DWER, 2019). WA government has recently classified 444 plant species as 'threatened flora', including 171 Critically Endangered, 151 Endangered, and 119 Vulnerable species, along with 16 species now listed as extinct. Similarly, 250 animal species have been listed as 'threatened fauna', comprising 59 Critically Endangered, 59 Endangered, and 132 Vulnerable, with 23 animal species considered extinct (State of Western Australia, 2024). There is an ongoing loss and degradation of biodiversity in WA, and knowledge about many species and ecosystems remains inadequate (EPA, 2007).

Despite WA's unique plants and animals that are found nowhere else, ecosystems and wildlife are declining, and significant areas of land are unmanaged, becoming further degraded by fire, feral animals, weed invasion and other threats (CCWA, 2021). Additionally, WA's environmental protection regime is governed by various pieces of legislation, leading to a fragmented, complex, and ineffective regulatory system (EDO, 2021; The Wilderness Society WA, 2021). The outdated *Wildlife Conservation Act 1950*, which was a revised version of the *Games Act 1912*, and the *Sandalwood Act 1929* have been replaced with the *Biodiversity Conservation Act 2016* (Bates, 2023). The *Environmental Protection Act 1986* and the *Biodiversity Conservation Act 2016* are the key environmental protection legislation in WA with similar functions to the EPBC Act at the Commonwealth level (EDO, 2021). However, a review of Western Australia's environment, planning, and cultural heritage laws against the EPBC Act's essential requirements concluded that WA's laws do not adequately meet the national requirement (EDO, 2021), indicating scope to strengthen policies and practices in environmental and biodiversity conservation in Western Australia.

[7] Fitzgerald River Ravensthorpe, Busselton Augusta, Central and Eastern Avon Wheatbelt, Mount Lesueur-Eneabba, Geraldton to Shark Bay Sand Plains, Camarvon Basin, Hamersley-Pilbara, and North Kimberley.

Table 4. Regulatory instruments of WA Government to conserve and manage biodiversity

Year	Regulatory instruments (plan, policy, act, guideline, and report)
1929	Sandalwood Act
1945	Soil and Land Conservation Act
1950	Wildlife Conservation Act
1972	Aboriginal Heritage Act
1976	Waterways Conservation Act
1984	Conservation and Land Management Act
1986	Environment Protection Act
1997	Land Administration Act
2005	Planning and Development Act
2007	Biosecurity and Agriculture Management Act
2007	The State of the Environment Report
2011	WA Environmental Offset Policy
2014	WA Environmental Offset Guidelines
2016	Biodiversity Conservation Act
2016	Aquatic Resources Management Act
2018	Biodiversity Conservation Regulations
2020	WA Climate Policy
2021	Supporting Continuous Improvement in ESG Outcomes for Western Australia
2021	Carbon Farming and Land Restoration Program
2022	WA Native Vegetation Policy
2023	WA Climate Adaptation Policy
2023	Climate Change Bill
2023	Sustainability Bond Framework (Issuance of first green bond worth 1.9 billion)
2024	WA Public Accounts Committee, Legislative Assembly, Report 11. Green and Gold: Securing economic growth with sustainable investment

6. What's next?

Following the WABSI model of program development pathway (Figure 7), issue identification, program instigation, end user engagement and management challenge scoping have been completed to develop a program plan in biodiversity economics and finance. The identified knowledge gaps through literature reviews and initial end user consultation will be further refined through research expertise consultation and knowledge gap identification through a series of sector-specific workshops with key end user groups and other relevant stakeholders for WA (e.g., primary producers, financial services, resources sector, and community sector). Finally, identified and prioritised knowledge gaps will be confirmed from the stakeholders to finalise the program for implementation.

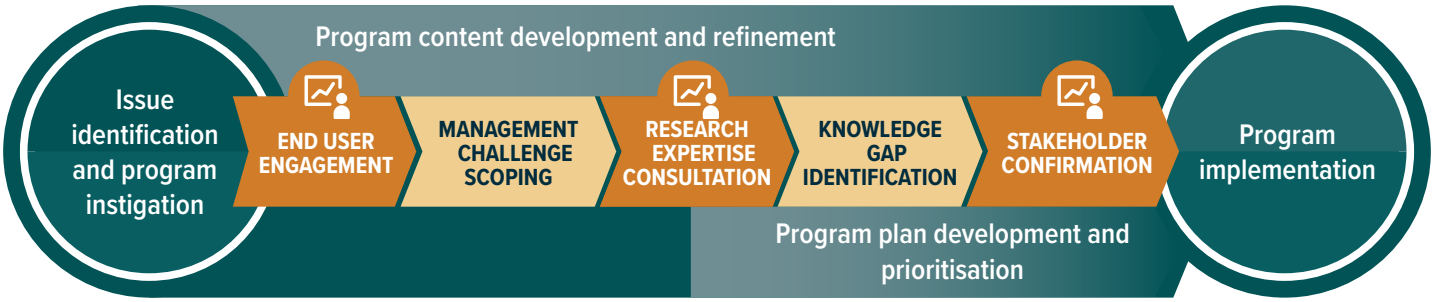

Figure 7. WABSI model of program development pathway

The literature reviews and initial engagement with end users and stakeholders have identified a range of knowledge gaps in biodiversity economics and finance. These knowledge gaps need to be addressed to mainstream biodiversity into economic and financial decisions at different levels across community, private and public sectors.

Key knowledge gaps in biodiversity economics relate to developing holistic valuation framework, understanding multiple or diverse values, identifying valuation methods to account for multifaceted and complex nature of biodiversity, developing user friendly and easy to apply tools to value biodiversity, integrating IPLC knowledge and values in decision-making, developing interdisciplinary collaboration to understand interdependencies and better management of nature. Additionally, understanding of the drivers of demand and supply of biodiversity certificate or credit would help to make better decisions in managing biodiversity. Similarly, addressing knowledge gaps related to biodiversity economics through integrating existing data, collecting new set of data, developing practical models or tools or frameworks, and experimenting with pilot projects and case studies would provide valuable insights to socially preferred conservation policy and practice.

From a biodiversity financing perspective, significant knowledge gaps remain to link finance flows with measurable biodiversity outcomes. These knowledge gaps include – finding broadly applicable and robust ways to measure biodiversity, defining metrics that are applicable to the broader context of biodiversity measurement; linking measurements to biodiversity outcome; assessing regulatory or policy impacts on biodiversity and financial flows; developing and standardising metrics and measurement techniques to assess biodiversity impact, dependencies, and financial risks; assessing effectiveness of different financing mechanisms in terms of biodiversity outcomes; establishing standardised reporting frameworks and guidelines for corporate nature-related impacts, dependencies, and risks; and identifying strategies and frameworks for scaling up successful biodiversity finance mechanisms, including public-private partnerships and innovative funding models.

The knowledge gaps or research needs for Australia and Western Australia in biodiversity economics and finance are mostly common to what are indicated in general literature. However, given the unique biogeography of Australia and Western Australia, the biodiversity they are bestowed with, and the type of major economic activities they engage with (e.g., mining, farming), the knowledge gaps or research needs in biodiversity economics and finance are also somewhat specific. Even though there are sector specific knowledge gaps, common knowledge gaps are related to understanding, measuring, and valuing biodiversity and nature, and integrating available knowledge in operational decisions at different decision-making levels using simple yet robust frameworks and tools. Scalable proof of concept, availability of data and models at low costs, measurement metrics and ways to measure or quantify impacts, dependencies, risks, and opportunities for businesses were some common research questions or knowledge gaps. Some specific questions that need further exploration in Australia and Western Australia are related to the Australian Government's Nature Positive plan and the Nature Repair market. What is the size of demand and supply of biodiversity credits/certificates? How would we provide confidence to the buyer on high integrity certificates, including permanency and additionality in practice? These are some important questions that need answers for a functioning biodiversity market to finance biodiversity conservation in Australia and Western Australia. In general, Western Australian economy is dependent on resources sector which underscores a further need to find ecologically and economically better ways to address biodiversity challenges by community, private and public sectors.

Given that a broader realisation of biodiversity loss is a material financial risk for businesses and the economic system, there is increased interest in identifying knowledge gaps, and to develop transition plans and actions to address them. In the context of an increased interest among investors and consumers on nature positive journey, governments will need to develop mechanisms to fulfill national and international commitments, goals, and targets. Addressing the knowledge gaps would enable efficient, cost-effective, and socially inclusive decisions on nature and biodiversity to ensure a nature positive future.

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Appendix 1

List of peer-reviewed articles reviewed as per inclusion/exclusion criteria

*(Note: * refers to the article highlighting knowledge or research gaps)*

Appendix 1a. Articles highlighting knowledge gaps in biodiversity economics (34/80)

1. Admiraal, J. F., Wossink, A., de Groot, W. T., & de Snoo, G. R. (2013). More Than Total Economic Value: How to Combine Economic Valuation of Biodiversity with Ecological Resilience [Article]. *Ecological Economics,* **89**,
2. *Allison, R., Sindhu, S., Konwar, P., Naidoo, L., & Yu, L. (2022). Introduction to Biodiversity Valuation Tools [Article]. *British Actuarial Journal,* **27**, 1–10.
3. Antongiovanni, M., Venticinque, E. M., Tambosi, L. R., Matsumoto, M., Metzger, J. P., & Fonseca, C. R. (2022). Restoration priorities for Caatinga dry forests: Landscape resilience, connectivity and biodiversity value [Article]. *Journal of Applied Ecology,* **59**(9), 2287–2298.
4. 4.Araia, M. G., Chirwa, P. W., & Syampungani, S. (2020). Do strictly protected areas protect vulnerable local tree species better than human land use? Disentangling conservation value from biodiversity value [Article]. *Journal for Nature Conservation,* **58**, 10.
5. Arthington, A. H., Godfrey, P. C., Pearson, R. G., Karim, F., & Wallace, J. (2015). Biodiversity values of remnant freshwater floodplain lagoons in agricultural catchments: evidence for fish of the Wet Tropics bioregion, northern Australia [Article]. *Aquatic Conservation-Marine and Freshwater Ecosystems*, **25**(3), 336–352.
6. Asah, S. T., & Blahna, D. J. (2020). Involving Stakeholders' Knowledge in Co-designing Social Valuations of Biodiversity and Ecosystem Services: Implications for Decision-Making [Article]. *Ecosystems*, **23**(2), 324–337.
7. Attum, O., Malkawi, S., & Hamidan, N. (2022). Factors contributing to the biodiversity value of an archaeological landscape in Jordan [Article]. *Herpetological Journal*, **32**(3), 102–108.
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9. *Bardsley, D. K., Palazzo, E., & Stringer, R. (2019). What should we conserve? Farmer narratives on biodiversity values in the McLaren Vale, South Australia [Article]. *Land Use Policy*, **83**, 594–605.
10. Bhat, M. Y., & Bhatt, M. S. (2019). Economic Valuation of Biodiversity in South Asia: The Case of Dachigam National Park in Jammu and Kashmir (India) [Article]. *Asia and the Pacific Policy Studies*, **6**(1), 59–72.
11. Bogan, M. T., Leidy, R. A., Neuhaus, L., Hernandez, C. J., & Carlson, S. M. (2019). Biodiversity value of remnant pools in an intermittent stream during the great California drought [Article]. *Aquatic Conservation-Marine and Freshwater Ecosystems*, **29**(6), 976–989.
12. *Borovik, K., & Pensini, P. (2022). Be Good to Your Mother (Earth): The Relationship between Anthropomorphising Nature, Financial Insecurity, and Support for Pro-environmental Policies in the Context of the Coronavirus Pandemic [Article]. *Current Research in Ecological and Social Psychology,* **3** *C7 – 100039*.
13. *Brazner, J., Walker, J., Mackinnon, F., & Cameron, R. (2023). Forested wetlands in a protected area and the adjacent working landscape provide complementary biodiversity value based on breeding birds: A case study from Nova Scotia, Canada [Article]. *Facets*, **8**, 1–31.
14. Brock, W., Kinzig, A., & Perrings, C. (2010). Modeling the Economics of Biodiversity and Environmental Heterogeneity [Article]. *Environmental & Resource Economics*, **46**(1), 43–58.
15. *Carrasco, L. R., Nghiem, T. P. L., Sunderland, T., & Koh, L. P. (2014). Economic valuation of ecosystem services fails to capture biodiversity value of tropical forests [Article]. *Biological Conservation*, **178**, 163–170.

16. Cimatti, M., Brooks, T. M., & Di Marco, M. (2021). Identifying science-policy consensus regions of high biodiversity value and institutional recognition [Article]. *Global Ecology and Conservation*, **32**, 13.

17. Cook, R. R., & Auster, P. J. (2013). The biodiversity value of marine protected areas for multi-species fishery management in the Gulf of Maine [Article]. *Aquatic Conservation-Marine and Freshwater Ecosystems*, **23**(3), 429–440.

18. Dasgupta, P. (2022). The Economics of Biodiversity: Afterword [Article]. *Environmental & Resource Economics*, **83**(4), 1017–1039.

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20. Entenmann, S. K., & Schmitt, C. B. (2013). Actors' perceptions of forest biodiversity values and policy issues related to REDD+ implementation in Peru [Article]. *Biodiversity and Conservation*, **22**(5), 1229–1254.

21. *Ernoul, L., & Wardell-Johnson, A. (2014). Adapting international conservation strategies to local context: Perceptions of biodiversity values and management responsibility in two Mediterranean deltas [Article]. *International Journal of Biodiversity Science, Ecosystem Services and Management*, **10**(4), 300–312.

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Appendix 1b. Articles highlighting knowledge gaps in biodiversity finance (12/13)

1. *Anyango-van Zwieten, N. (2021). Topical themes in biodiversity financing [Review]. *Journal of Integrative Environmental Sciences*, **18**(1), 19–35.
2. *Barral, S. (2021). Conservation, finance, bureaucrats: managing time and space in the production of environmental intangibles [Article]. *Journal of Cultural Economy*, **14**(5), 549–563.
3. *Beer, C. M. (2023). Bankrolling biodiversity: The politics of philanthropic conservation finance in Chile [Article]. *Environment and Planning E-Nature and Space*, **6**(2), 1191–1213.
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6. *Cosma, S., Rimo, G., & Cosma, S. (2023). Conservation finance: What are we not doing? A review and research agenda [Review]. *Journal of Environmental Management*, **336**, 14.
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9. *Hutchinson, M. C., & Lucey, B. (2024). A bibliometric and systemic literature review of biodiversity finance [Review]. *Finance Research Letters*, **64** C7 – 105377.
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11. *Kay, K. (2018). A Hostile Takeover of Nature? Placing Value in Conservation Finance [Article]. *Antipode*, **50**(1), 164–183.
12. *Phelps, J., Webb, E. L., & Koh, L. P. (2011). Risky business: An uncertain future for biodiversity conservation finance through REDD+ [Article]. *Conservation Letters*, **4**(2), 88–94.
13. *Sánchez-Fernández, D., Abellán, P., Aragón, P., Varela, S., & Cabeza, M. (2018). Matches and mismatches between conservation investments and biodiversity values in the European Union [Article]. *Conservation Biology*, **32**(1), 109–115.

Appendix 1c. Articles highlighting knowledge gaps in both biodiversity economics and finance (3/7)

1. Barbier, E. B. (2022). The Policy Implications of the Dasgupta Review: Land Use Change and Biodiversity: Invited Paper for the Special Issue on "The Economics of Biodiversity: Building on the Dasgupta Review" in Environmental and Resource Economics. *Environmental & Resource Economics*, **83(**4), 911–935.
2. *Berzaghi, F., Cosimano, T., Fullenkamp, C., Scanlon, J., Fon, T. E., Robson, M. T., Forbang, J. L., & Chami, R. (2022). Value wild animals' carbon services to fill the biodiversity financing gap [Editorial Material]. *Nature Climate Change*, **12**(7), 598–601.
3. *De Valck, J., & Rolfe, J. (2019). Comparing biodiversity valuation approaches for the sustainable management of the Great Barrier Reef, Australia [Review]. *Ecosystem Services*, **35**, 23–31.
4. Dempsey, J., & Bigger, P. (2019). Intimate Mediations of For-Profit Conservation Finance: Waste, Improvement, and Accumulation [Article]. *Antipode*, **51**(2), 517–538.
5. McFarland, B. J. (2015). International Finance for REDD+ Within the Context of Conservation Financing Instruments [Article]. *Journal of Sustainable Forestry*, **34**(6-7), 534–546.
6. *Overton, J. M., Stephens, R. T. T., & Ferrier, S. (2013). Net Present Biodiversity Value and the Design of Biodiversity Offsets [Article]. *Ambio*, **42**(1), 100–110.
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Appendix 2

List of key grey literature reviewed in biodiversity economics and finance

Appendix 2a. Grey literature reviewed on biodiversity economics

1. CBD. (2022). *Kunming-Montreal Global biodiversity framework. In: Draft decision submitted by the President*. Convention on Biological Diversity, CBD/COP/DEC/15/4, Montreal, Canada.
2. Dasgupta, P. (2021). *The Economics of Biodiversity: The Dasgupta Review*. London: HM Treasury.
3. IPBES. (2019). *Global Assessment Report on Biodiversity and Ecosystem Services*. IPBES secretariat, Bonn, Germany.
4. IPBES. (2022). *Methodological Assessment Report on the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. IPBES secretariat, Bonn, Germany.
5. MEA. (2005). *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC.
6. OECD. (2018). *Mainstreaming Biodiversity for Sustainable Development*. OECD Publishing, Paris.
7. OECD. (2020). *A Comprehensive Overview of Global Biodiversity Finance*. Organisation for Economic Cooperation and Development (OECD) Environment Directorate.
8. OECD. (2023a). *Assessing Biodiversity-Related Financial Risks: Navigating the Landscape of Existing Approaches*. OECD Environment Directorate.
9. OECD. (2023b). *A supervisory framework for assessing nature-related financial risks: Identifying and navigating biodiversity risks, OECD Business and Finance Policy Papers*. OECD Publishing, Paris.
10. TEEB. (2010). *The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature, A Synthesis of the Approach, Conclusions and Recommendations of TEEB*. The Economics of Ecosystems and Biodiversity (TEEB), Progress Press, Malta.
11. TNFD. (2023). *Recommendations of the Taskforce on Nature-related Financial Disclosures*. Taskforce on Nature-related Financial Disclosures.
12. Tobin-de la Puente, J., & Mitchell, A. W. (2021). *The Little Book of Investing in Nature*. Global Canopy: Oxford.

Appendix 2b. Grey literature reviewed on biodiversity finance

1. AfN. (2024). *Alignment of the Accounting for Nature® Framework with other Global Frameworks, Standards & Goals– Version 2.0*. Accounting for Nature Ltd.
2. CBD. (2024). *Exploration of the biodiversity finance landscape*. Convention on Biological Diversity, CBD/SBI/4/INF/10, Nairobi.
3. EcoAct. (2024). *The Big eBook of Sustainability Reporting Frameworks*. Ecoact.
4. FfB. (2024). *Aligning Financial Flows with the Global Biodiversity Framework: Translating Ambition into Implementation, Key Recommendations for Governments from the Financial Sector*. The Finance for Biodiversity (FfB) Foundation.
5. IFC. (2023). *Biodiversity Finance Reference Guide: Building on the Green Bond Principles and Green Loan Principles*. International Finance Corporation, Washington, D.C.
6. KPMG. (2023). *The Investment Case for Nature: An Overview of Investment Strategies for Closing the Nature Finance Gap*. KPMG International.
7. Lammerant, J., Driesen, K., Verhelst, J., Ryck, J. D., & Verstraeten, Y. (2022). *Assessment of Biodiversity Measurement Approaches for Businesses and Financial Institutions, Update Report 4 on behalf of the EU Business & Biodiversity Platform*.
8. Lammerant, J., Vanderheyden, G., & Verhelst, J. (2024). *Biodiversity Disclosure Initiatives: Thematic Report on behalf of the EU Business & Biodiversity Platform, Updated Version 1st August 2024*
9. NGFS. (2023a). *Nature-related Financial Risks: A Conceptual Framework to Guide Action by Central Banks and Supervisors*. Network for Greening the Financial System.
10. NGFS. (2023b). *Recommendations toward the Development of Scenarios for Assessing Nature-Related Economic and Financial Risks*. Network for Greening the Financial System.
11. NGFS & INSPIRE. (2021). *Biodiversity and Financial Stability: Exploring the Case for Action*. Network for Greening the Financial System (NGFS) and The International Network for Sustainable Financial Policy Insights, Research, and Exchange (INSPIRE).
12. OECD. (2020). *A Comprehensive Overview of Global Biodiversity Finance*. Organisation for Economic Cooperation and Development (OECD) Environment Directorate
13. OECD. (2023a). *Assessing Biodiversity-Related Financial Risks: Navigating the Landscape of Existing Approaches*. OECD Environment Directorate.
14. OECD. (2023b). *A supervisory framework for assessing nature-related financial risks: Identifying and navigating biodiversity risks, OECD Business and Finance Policy Papers*. OECD Publishing, Paris.
15. POLLINATION. (2024). *Nature-Positive Strategy: Practical Guidance for Corporates*.
16. TNFD. (2023). *Recommendations of the Taskforce on Nature-related Financial Disclosures*. Taskforce on Nature-related Financial Disclosures.
17. Tobin-de la Puente, J., & Mitchell, A. W. (2021). *The Little Book of Investing in Nature*. Global Canopy: Oxford.
18. World Bank. (2021). *The Economic Case for Nature: A global Earth-Economy Model to Assess Development Policy Pathways*. International Bank for Reconstruction and Development / The World Bank, Washington DC.
19. World Bank Group. (2020). *Mobilizing Private Finance for Nature: A World Bank Group Paper on Private Finance for Biodiversity and Ecosystem Services*. The World Bank Group, Washington, DC.
20. UNDP. (2018). *The BIOFIN Workbook 2018: Finance for Nature. The Biodiversity Finance Initiative*. United Nations Development Programme: New York.
21. UNEP-WCMC, Capitals Coalition, Arcadis, ICF, & Europe, W. (2022). *Recommendations for a standard on corporate biodiversity measurement and valuation, Aligning accounting approaches for nature*.
22. UNEPFI. (2023a). *Banking on Nature: What the Kunming-Montreal Global Biodiversity Framework Means for Responsible Banks*. UN Environment Programme Finance Initiative, Geneva.

23. UNEPFI. (2023b). UN Environment Programme Finance Initiative Pilots in Support of TNFD, Insights into Deep-Dive UNEP FI Pilots to Ensure Effective Uptake of the Final TNFD Framework.
24. UNEPFI. (2024). Accountability for Nature: Comparison of Nature-Related Assessment and Disclosure Frameworks and Standards.
25. WEF. (2020a). The Future of Nature and Business. World Economic Forum, Geneva, Switzerland.
26. WEF. (2020b). Nature Risk Rising: Why the Crisis Engulfing Nature Matters for Business and the Economy. World Economic Forum, Geneva, Switzerland.
27. WEF. (2023). The Post-2020 Global Biodiversity Framework and What it Means for Business: White Paper. World Economic Forum, Geneva, Switzerland.
28. WEF & Wyman, O. (2024). Financing the Nature-Positive Transition: Understanding the Role of Banks, Investors and Insurers, CEO Briefing.

Appendix 3

Key literature reviewed to gain Australia-specific insights on biodiversity economics and finance

1. ACF. (2022a). *Aggravating extinction: How the Australian government is greenlighting destruction of the habitat our threatened species need to survive*. Australian Conservation Foundation.
2. ACF. (2022b). *Reversing nature destruction in Australia: Five improvements we must make*. Australian Conservation Foundation.
3. ACF. (2024a). *Extinction Wrapped 2023*. Australian Conservation Foundation.
4. ACF. (2024b). *Risky Business: How Australian financial institutions are managing nature-related risks and opportunities, 2024 progress report*. Australian Conservation Foundation.
5. ACF. (2024c). *Set and forget: How offsets under national environmental law drive habitat destruction*. Australian Conservation Foundation.
6. ACF, Pollination, & AEI. (2022). *The Nature-Based Economy: How Australia's Prosperity Depends on Nature*. Australian Conservation Foundation (ACF), Pollination and Australian Ethical Investments (AEI).
7. ACSI. (2021). *Biodiversity Unlocking Natural Capital Value for Australian Investors*. The Australian Council of Superannuation Investors.
8. ASFI. (2020). *Australian Sustainable Finance Roadmap: A plan for aligning Australia's financial system with a sustainable, resilient and prosperous future for all Australians*. The Australian Sustainable Finance Initiative.
9. Biodiversity Council. (2023). *Delivering on nature positive: 10 essential elements of national environmental law reform.*
10. Biodiversity Working Group. (2017). *Australia's Strategy for Nature 2019–2030, Commonwealth of Australia 2019*.
11. Climateworks Centre. (2022). *Living within limits: Adapting the planetary boundaries to understand Australia's contribution to planetary health*.
12. Cresswell, I. D., Janke, T., & Johnston, E. (2021). *Australia State of the Environment 2021: Overview, Independent Report to the Australian Government Minister for the Environment, Commonwealth of Australia, Canberra*.
13. CSIRO. (2014). *Biodiversity : science and solutions for Australia. CSIRO Publishing, Australia*.
14. DCCEEW. (2022a). *Nature Positive Plan: Better for the Environment, Better for Business*. Department of Climate Change, Energy, the Environment and Water, Canberra.
15. DCCEEW. (2022b). *TNFD Pilots – Australian Case Study Report*. Department of Climate Change, Energy, the Environment and Water, Canberra.
16. DEWHA. (2010). *Ecosystem Services: Key Concepts and Applications, Occasional Paper No 1*. Department of the Environment, Water, Heritage and the Arts, Canberra.
17. Dielenberg, J., Bekessy, S., Cumming, G. S., Dean, A. J., Fitzsimons, J. A., Garnett, S., Goolmeer, T., Hughes, L., Kingsford, R. T., Legge, S., Lindenmayer, D. B., Lovelock, C. E., Lowry, R., Maron, M., Marsh, J., McDonald, J., Mitchell, N. J., Moggridge, B. J., Morgain, R., . . . Wintle, B. A. (2024). Australia's biodiversity crisis and the need for the Biodiversity Council. *Ecological Management & Restoration*, **24**(2–3), 69–74.
18. DSEWPC. (2012). *Environment Protection and Biodiversity Conservation Act 1999: Environmental Offsets Policy*. Department of Sustainability, Environment, Water, Population and Communities, Australian Government.

19. EDO, & PYL. (2020). *Devolving Extinction? The Risks of Handing Environmental Responsibilities to States & Territories*. Environmental Defenders Office and Places You Love.

20. Legge, S., Rumpff, L., Garnett, S. T., & Woinarski, J. C. Z. (2023). Loss of terrestrial biodiversity in Australia: Magnitude, causation, and response. *Science*, **381**, 622–631.

21. OECD. (2019). *OECD Environmental Performance Reviews: Australia*. OECD Publishing, Paris.

22. PwC. (2022). *A nature-positive Australia: The value of an Australian biodiversity market*. PricewaterhouseCoopers (Australia).

23. The Australian Government the Treasury. (2024). *Sustainable Finance Roadmap.* The Australian Government the Treasury.

24. The Treasury, & Australian Office of Financial Management. (2023). *Australian Government Green Bond Framework.*

Appendix 4

Key literature reviewed to gain Western Australian-specific insights on biodiversity economics and finance

1. Bailey, J., Harris, T., & Jennings, P. (2018). State of the environment reporting in Western Australia: law, land and beyond. *Australasian Journal of Environmental Management*, **25**(4), 371–384.
2. CCWA. (2021). *A bold vision for conservation, climate and communities in WA*.
3. DEC. (2006). *Draft – A 100-year Biodiversity Conservation Strategy for Western Australia: Blueprint to the Bicentenary in 2029*. Department of Environment and Conservation, Government of Western Australia.
4. DMIRS. (2023). *Mining Rehabilitation Fund, Yearly report 2022–23*. Department of Mines, Industry Regulation and Safety, Government of Western Australia.
5. DWER. (2019). *Native Vegetation in Western Australia: Issues paper for public consultation*. Department of Water and Environmental Regulation, Government of Western Australia. https://www.wa.gov.au/system/files/2021-09/Native_Vegetation_in_Western_Australia_Issues_paper.pdf
6. DWER. (2021). *Native vegetation in Western Australia: Issues paper consultation summary*. Department of Water and Environmental Regulation, Government of Western Australia.
7. DWER. (2022). *Native vegetation policy for Western Australia*. Department of Water and Environmental Regulation, Government of Western Australia. https://www.wa.gov.au/system/files/2022-07/Native-vegetation-policy-for-Western-Australia.pdf
8. EDO. (2021). *Effectiveness of WA Environmental Protection Laws*. Environmental Defenders Office.
9. EPA. (2007). *State of the Environment Report: Western Australia 2007*. Department of Environment and Conservation, Perth, Western Australia.
10. The Wilderness Society WA. (2021). *7 ways to protect WA's most valuable natural asset*.

Appendix 5

Stakeholders /agencies consulted (number of persons)

1. Government departments (e.g., WA Treasury, Department of Biodiversity Conservation and Attractions, Department of Environment Regulation and Water, Department of Primary Industries and Regional Development) (13)
2. Natural Resource Management (NRM) groups (5)
3. Resource companies (8)
4. Financial institutions/accounting firms (11)
5. Environmental consultants/consulting firms (8)
6. Research institutions — universities, CSIRO (15)
7. Community organisations and individuals (7)

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Department of Jobs, Tourism, Science and Innovation

Department of Water and Environmental Regulation