Investing for Impact

Mainstreaming biodiversity in impact investments in the forest sector

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Abstract

Global levels of biodiversity are declining at alarming rates. While this biodiversity crisis is widely acknowledged, efforts to curb biodiversity loss remain inadequate. Part of the reason is the lack of funding for conservation efforts. Impact investments have been advocated as the solution and alternative to public funding. However, it is unclear how impact investments in the forest sector can create a positive impact on biodiversity and how this can be assessed by investors. Therefore, this research aimed to develop an impact framework that guides investors in their analysis. This may aid in the mainstreaming of biodiversity in the impact investing narrative.

A systematic literature survey on social-ecological systems resilience provided specific recommendations. Semi-structured expert interviews with practitioners helped placing the framework in the context of impact investing in the forest sector. Many experts stressed the importance of certification or reporting standards. They also discussed how impact investing revolves about balancing risks, return and impacts.

In the end, specific criteria and indicators for the impact framework were derived from the literature survey and expert interviews. Based on seven social-ecological resilience principles, 20 criteria with 31 associated indicators were developed and presented in an impact framework. This framework was then tested on two forestry companies that served as real-life examples of impact investments in the forest sector. As it turns out, there is some overlap between the framework and the forestry companies. Still, there is room for more intentionality, additionality and measurability in the practices and reporting of impact investments in the forest sector. Forest companies may also benefit from adopting a social-ecological resilience approach as it can combine social and environmental impacts in a way that speaks to investors.

List of abbreviations and acronyms

AUM	assets under management
CAS	Complex Adaptive System
CBD	Convention on Biological Diversity
CCB	Climate, Community & Biodiversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CSR	Corporate Social Responsibility
DNB	De Nederlandse Bank (*Dutch Central Bank*)
ESG	Environmental, Social and Governance
ESIA	Environmental and Social Impact Assessment
ESMS	Environmental and Social Management System
EU	European Union
EUR	Euro
FAO	Food and Agriculture Organization of the United Nations
FMO	Financierings-Maatschappij voor Ontwikkelingslanden (*Dutch entrepreneurial development bank*)
FPIC	Free, Prior and Informed Consent
FSC	Forest Stewardship Council
GBF	Global Biodiversity Framework
GCF	Green Climate Fund
GDP	gross domestic product
GIIN	Global Impact Investing Network
HCV	High Conservation Value
IBAT	Integrated Biodiversity Assessment Tool
IFC	International Finance Corporation
IFC-PS	International Finance Corporation Performance Standards
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IRIS	Impact Reporting and Investment Standards
IUCN	International Union for Conservation of Nature
LKTS	lesser-known timber species
LPI	Living Planet Index
MADES	Ministerio del Ambiente y Desarrollo Sostenible (*Ministry of Environment and Sustainable Development Paraguay*)
NGO	non-governmental organisation
NTFP	non-timer forest product
OECD	Organisation for Economic Co-operation and Development
PBAF	Partnership for Biodiversity Accounting Financials
PEFC	Programme for Endorsement of Forest Certification Schemes
PES	payment for ecosystem services
SDG	Sustainable Development Goal
SER	social-ecological resilience
SES	social-ecological system
SFDR	Sustainable Finance Disclosure Regulation
SFI	Sustainable Forestry Initiative
SINASIP	Sistema Nacional de Áreas Protegidas del Paraguay (*National System of Protected Areas of Paraguay*)
SRI	Socially Responsible Investing
SSC	Stand Structural Complexity

TNFD	Taskforce on Nature-related Financial Disclosures
UN	United Nations
UNEP	United Nations Environment Programme
UNEP-WCMC	United Nations Environment Programme World Conservation Monitoring Centre
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USD	United States dollar
VCS	Verified Carbon Standard
WEF	World Economic Forum
WoS	Web of Science
WWF	World Wide Fund for Nature

Contents

Abstract

List of abbreviations and acronyms

1 Introduction ... 1

1.1 Research aim & questions ... 5

2 Theoretical framework ... 7

2.1 Biodiversity ... 7

2.2 Social-Ecological Systems and Resilience ... 7

2.3 Conceptual framework ... 10

3 Methods ... 12

3.1 Methodology ... 12

3.2 Data collection ... 13

3.3 Data analysis ... 16

4 Results ... 20

4.1 Impact investing in the forest sector ... 20

4.2 Criteria & indicators ... 22

5 Impact framework ... 30

5.1 Setting the scene ... 30

5.2 The impact framework ... 31

6 Testing the framework ... 38

6.1 Findings ... 38

7 Discussion ... 46

7.1 Impact investing ... 46

7.2 Reflection on research ... 47

8 Conclusion and recommendations ... 49

8.1 Recommendations ... 49

9 References ... 51

Appendices ... 67

A: List of papers included in the final database of the literature survey ... 67

B: List of interview organisations ... 69

C: Interview topic list and guiding questions ... 70

D: Background information about the author ... 72

E: Table of all the operationalisation of resilience principles in literature ... 73

F: Table of all the disturbances identified in the literature ... 76

1 Introduction

Global levels of biodiversity are declining at alarming rates. We may even be living in the sixth mass extinction caused by humans (Ceballos et al., 2015). The Living Planet Index (LPI) shows a decline of 64% in the abundance of vertebrate species populations globally since 1970 (WWF, 2020). Considering only certain regions such as Latin America this number can be as high as 94%. Between 2010 and 2020 the world also saw a net forest loss of 4.74 million hectares (FAO & UNEP, 2020). Despite initiatives to reverse these trends, efforts remain inadequate. Part of the reason is the lack of financial resources to fund these efforts. The conservation, restoration and sustainable use of biodiversity and ecosystems require funding urgently. This need for funding has even been included in the UN Sustainable Development Goals (SDGs) (targets 15.a and 15.b). Currently, more funding is needed than is available. Finance needed for global biodiversity conservation is estimated to be anywhere from USD 700 billion (CBD, 2022) up to USD 722-967 billion per year (Deutz et al., 2020; Barbier, 2022). Though, annual investments for biodiversity were about USD 121 billion on average (0.21% of global GDP) from 2008-2017 (Seidl et al., 2020). Estimates from 2019 show figures of USD 124 to 143 billion (Deutz et al., 2020). These figures point towards underfunding and show that funding mechanisms have to be scaled up to bridge the funding gap.

This need to increase funding is reflected in the Post-2020 Global Biodiversity Framework (GBF). This framework has been adopted at the 15th Conference of Parties (COP-15) to guide action towards 2030. The GBF sets out the plan to scale up financial resources to USD 200 billion per year and include private finance. Though this money is much needed, achieving this target would still be insufficient to close the estimated funding gap. At the same time, the previous targets set by the CBD, the Aichi biodiversity targets, have all not been (fully) achieved (Secretariat of the CBD, 2020). This highlights the role of the private sector to take immediate action and await government implementation of the GBF.

Some of this is has already been playing out in practice. As an alternative, and in addition to public expenditure, private sector funding is being mobilised. An example of private sector funding is impact investments which have been advocated as a way to bridge the funding gap by attracting private finances and leveraging public expenditure (Clark et al., 2018). The Global Impact Investing Network (GIIN) defines impact investments as “investments made with the intention to generate positive, measurable social and environmental impact alongside a financial return” (Bass et al., 2020, p.61). The concept of impact investing came about around 2007/2008 with the intention to involve the private sector in funding development and conservation (Bugg-Levine & Goldstein, 2009). The inadequacy of public funding (McCarthy et al., 2012; Xu et al., 2021) was already recognised at the time.

Despite advancements within the impact investing sector, such as developments of impact metric systems (Clarkin & Cangioni, 2016) and its growing popularity over the years, the approach is not standardised and the concept remains subject to different interpretations (Hockerts et al., 2022). There are other concepts that have been used in the same way, such as social finance, while other concepts related to ‘responsible’ investing like Corporate Social Responsibility (CSR), Socially Responsible Investing (SRI) and Environmental, Social and Governance (ESG) investing may also contribute to the confusion (Agrawal & Hockerts, 2021). Even though these all slightly differ in their focus and use, concepts like social investment have been used synonymously with impact investment (Höchstädter & Scheck, 2015).

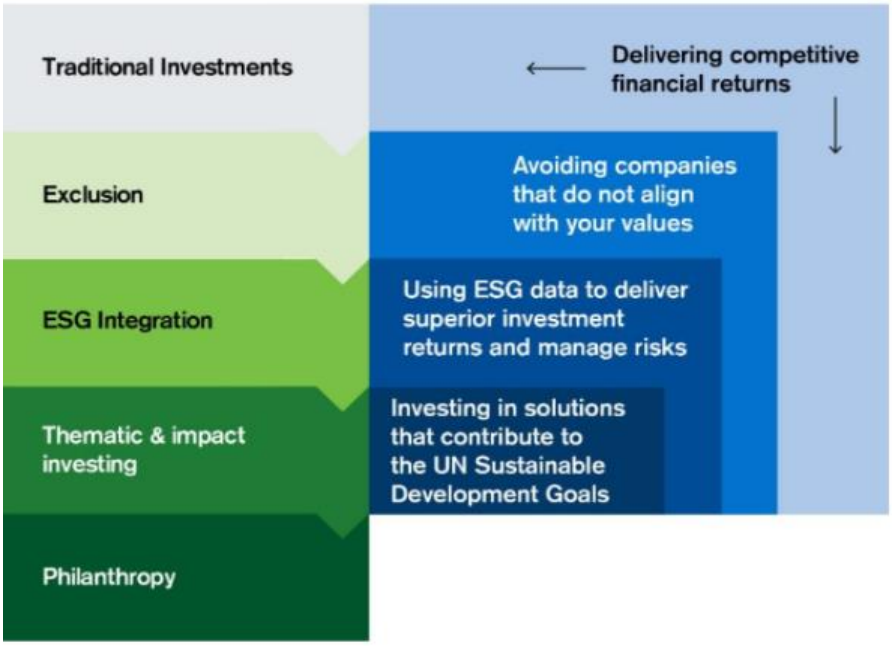

Figure 1: Sustainable investing spectrum. Adopted from Credit Suisse (n.d.).

Figure 1 sheds some light on the 'sustainable investment spectrum' and the position of impact investing in this. As shown here, impact investing is positioned between ESG integration and philanthropy. Although philanthropy and impact investing can set similar social and/or environmental goals, philanthropy lacks a focus on financial returns (Roundy et al., 2017). ESG integration, on the other hand, is mainly focussed on the exclusion of companies that do not meet certain core values of the investor and on improving the risk-return balance (Giese et al., 2019). What sets impact investors apart from other types of investors are the following criteria (Eurosif, 2018; IFC, 2021):

- *Intentionality:* The intention of an investor to create positive social and/or environmental impact through the investment;
- *Additionality:* The investment or actions by the investor have impact beyond the mere provision of capital;
- *Measurement:* A measurement framework is in place that links investments to outcomes in a transparent way.

The value of impact investing therefore lies in its effort to move from negative screening and avoiding companies that do not align with core values to creating a positive impact. In other words, the investor moves from avoiding negative impact to creating positive impact. In creating a positive impact, it is key to understand the notion of additionality as it is used here. Additionality means that "the investment must increase the quantity or quality of the social or environmental outcome beyond what would otherwise have occurred. The counterfactual is that ordinary, socially neutral investors would have provided the same capital in any event." (Brest & Born, 2013, p.25). Hence, impact investors offer something that 'neutral' or traditional investors do not. An example could be to engage with investees about adverse activities and to press for change (Agrawal & Hockerts, 2019). Investees can thus be urged to take action in reducing, or reverting, for example their emissions, pollution or deforestation rates.

Due to ambiguity surrounding which assets count as impact investments and who as an impact investor, the total market size is difficult to determine (IFC, 2021). Despite this, the IFC (2021) has estimated the total market size of impact investments that include all three characteristics (intentionality, additionality and measurement) at USD 636 billion in 2020. This is a growth of about 26% from USD 505 billion in 2019. This trend of growth is in line with the wider literature that points

at a growing market size of impact investments (Eurosif, 2018; Gaggiotti & Gianoncelli, 2022; Hand et al., 2020). A survey amongst members of the GIIN found that about 55% of global impact assets under management (AUM) are managed by organisations headquartered in Western, Northern & Southern Europe and about 37% by those in the U.S. & Canada (Hand et al., 2022). This suggests Europe is the leading region in mobilising impact investments. Within Europe, the Netherlands is a relatively large impact investing market, and so, could be a leader of change (Eurosif, 2018; Wessemius-Chibrac et al., 2022). While impact investing currently only constitutes a niche market, these size and growth figures suggest there is huge upside potential for the global impact investing market (IFC, 2021). Considering only the first criterium of intentionality, there are an estimated USD 308 billion privately managed and USD 1.338 trillion publicly managed investments with 'intended' impact (IFC, 2021). Though, one should not immediately consider the category of 'intended' impact investments the same as impact investments that include all three characteristics above. The intended impact investments lack the credibility and transparency necessary to prove that investments are really having additional impact. The absence of a measurement system makes such investments also prone to *impact washing* (Busch et al., 2021). This means that impact is claimed but not shown and thus any investor can use the banner of impact investing to appear more sustainable or responsible. So to meaningfully contribute to the impact investing market, investors need to show what the added benefits of impact investments are and account for these in a transparent way.

Though the three common characteristics serve as an important foundation for impact investments, they can be operationalised in different ways. Given the diversity of environmental and social problems, also investors that aim to address these come in different varieties. In fact, in a survey by the GIIN, only a third of impact investors claimed to set ecosystems and biodiversity targets (Bass et al., 2020). Therefore, not all impact investments will necessarily benefit biodiversity. Other, more popular target categories include employment, agriculture, health, education and climate (Bass et al., 2020). Impact investing may be scalable but its operationalisation remains diverse due to this diversity of targets and an unstandardised approach (Castellas et al., 2018). A key challenge underpinning the integration of biodiversity into impact investing is the difficulty of measurement and showing additionality (Thompson, 2023). There are a wide variety of variables and methods in measuring biodiversity (Moreno et al., 2017). It is not always clear *what* is to be measured. Do we only measure endangered species, total species richness or abundance, or even a combination? Secondly, how should these variables be measured, and how often? These questions all add to the difficulty of setting biodiversity targets. An investor not only has to choose which goals to strive for, he/she also needs to find a way of measuring progress towards this goal. This leaves much room for the selection of targets and in the interpretation of impact. It is essentially up to the investor how to define and measure impact.

A common approach for investors is to pick one or multiple of the 17 SDGs as their main target (Pineiro et al., 2018; Hand et al., 2020). As a result, putting an effort in curbing biodiversity loss (and any other goal for that matter) remains optional. Despite this, the dependence of society and the economy on nature or biodiversity is being discussed by the financial sector in the Netherlands (Urbach et al., 2021; Van Oorschot et al., 2020; Van Toor et al., 2020) sending the message that investors should take biodiversity into account more often. Despite this growing awareness, impact investors in the Netherlands mainly target climate action and decent work and economic growth, while life on land and below water remain the least popular SDGs to target (Wessemius-Chibrac et al., 2022). Though this thesis mainly focusses on biodiversity, it does not ignore the interdependence the environment and society (Isbell et al., 2017; Reyers & Selig, 2020). Many drivers of biodiversity loss are caused by human action. For example, forest biodiversity loss is mainly caused by agricultural expansion and overexploitation (FAO & UNEP, 2020). So biodiversity conservation in forests should go hand in hand with sustainable agriculture and timber production (Dudley & Alexander, 2017).

Following this line of thinking, there are impact investors who aim to combine social and environmental impact and have a positive effect on biodiversity. ASN Impact Investors is one of such. Similar to ASN Bank, it has made biodiversity one of its three investment pillars alongside human rights and climate (ASN Bank, 2021b). ASN Impact Investors is one of the spearheading asset managers in

impact investing, especially in the Netherlands or Europe. In November 2021, ASN Impact Investors launched their Biodiversity Fund ("*Biodiversiteitsfonds*"). Currently the fund has a size of about EUR 28.6 million and was specifically set up to promote biodiversity protection and restoration (ASN Impact Investors, 2022). This in line with the goal of ASN Bank to be net biodiversity positive by 2030 which is explained as the sum of activities producing more benefit than harm for biodiversity, thereby being, on balance, net positive (ASN Bank, 2021a).

One way in which the ASN Biodiversity Fund aims to create positive impact for biodiversity is by investing in forests. This is no surprise given the fact that forests harbour most of the Earth's terrestrial biodiversity. About 80% of amphibian species, 75% of bird species, and 68% of the world's mammal species live in forests (FAO & UNEP, 2020). Investing in forests is therefore necessary to protect this biodiversity. The UN Biodiversity Finance Initiative has estimated that an additional USD 19 to 32 billion is needed for sustainable forestry (BIOFIN, 2021). The problem with investments for biodiversity is that biodiversity itself does not provide financial returns. Biodiversity is not a commodity that can be bought and sold, rather biodiversity facilitates other revenue streams. For example, agriculture, timber and ecotourism all depend on biodiversity (OECD, 2019). Hence, these alternatives are needed to cover the (opportunity) costs of biodiversity conservation. So at the moment, several common revenue strategies in forestry are (but not limited to) timber sales, sales of carbon offsets, sales of non-timber forest products (NTFPs) and leasing of land (Bass et al., 2019). The concept of biodiversity credits or offsets seeks to overcome this by providing a way of 'selling' biodiversity conservation directly. Biodiversity credits work similar to carbon credits where anyone can buy credits to compensate for their biodiversity impact and achieve no net loss (Bull et al., 2013). However, this comes with many challenges of its own (Reeves-Evison & Bowsher, 2020). The problem revolves around capturing biodiversity in a tradable unit and accrediting this a monetary value. Debates on biodiversity offsets are still ongoing while their use remains contested (Githiru et al., 2015) and subject to interpretation (Kigonya, 2022).

While projects that combine conservation and exploitation seem possible, investors willing to fund such projects face the challenge of finding successful examples. An impediment to the scaling of impact investments is the lack of actors "that have the capacity to identify and design investments that fit the local conservation needs and translate them into a proposal that appeals to the financial sector" (De Blas & Kettunen, 2019, p.14). The absence of such actors rather than the absence of capital seems to be the cornerstone of the funding gap (IFC, 2019). While there may be good conservation initiatives out there, these do not always seem 'bankable'. It is almost as if conservationists and investors speak different languages (Begemann et al., 2023). Bringing them together requires knowledge of forestry and conservation whilst being able to put this in a narrative that speaks to investors. For investors, it is essential to know what they are investing in and how their money can have the largest possible impact. The associated challenge is knowing what constitutes a 'positive impact'. A standardised evaluation framework can serve this purpose by guiding investors to more impactful investments (Lam & Tan, 2021).

Standards on measuring biodiversity impacts are already being developed. The partnership for biodiversity accounting financial (PBAF) was initiated to develop a standardised biodiversity accounting approach for the financial sector (PBAF Netherlands, 2020). Currently, they are working on a mechanism to implement this in practice. Other initiatives that provide standardised guidelines on impact accounting and reporting include the Impact Reporting and Investment Standards (IRIS) and Taskforce on Nature-related Financial Disclosures (TNFD) Framework. IRIS was developed by the Global Impact Investing Network (GIIN) and was later updated to the new standard IRIS+ (with the '+'). Yet, these standards measure the realised (negative) impact of investments. It does not always help an investor in selecting investments during the screening or due diligence phase. For this, an investor would need to be able to know how positive impact is created. This is especially relevant for newly established projects or funds that have no track record yet. Many companies and funds are only starting with biodiversity accounting so very limited data is available on biodiversity outcomes as of now (Addison et al., 2018; Panwar et al., 2022). Often there is a lack of track records by potential investees which limits data availability for investors (Studer-Noguez, 2021). This means that before

investing, no biodiversity outcomes can be evaluated as they are simply not there yet or because no data is available. Another argument for estimating impact beforehand, is that after making the investment the money is already invested. If it turns out that the impact was not as great as expected, or even negative, it will be too late. Furthermore, the reporting standards already mentioned are generic standards, not pointing direction to what each sector should do to deal with uncertainty and create positive impact on biodiversity. When evaluating potential impact, there may be a "need to engage with investees and the need to draft biodiversity related conditions for a loan or investment agreement" (PBAF, 2022, p.31). For an investor looking to invest in the forestry sector, it is still not very clear what these biodiversity conditions should be. This investor should have guidance on how biodiversity impact of potential investments could be maximised. A biodiversity impact assessment framework therefore has to be based on the efforts a company will make. In essence it is an assessment of the policy and future action of a company. For forest companies, it is therefore necessary to formulate objectives and disclose intended future activities. To the best of my knowledge, there is no framework available that specifically focusses on forestry companies and their biodiversity outcomes in relation to social aspects and financial returns.

Such tailored framework can also show how additionality can be created in specific cases. A 'neutral' investor simply invests without taking impact into account while an impact investor who implements the framework seeks to actively create or support positive impact. The standardised framework would allow for comparison between investments and reduce the risk of greenwashing (Popescu et al., 2021). A widely adopted framework will make sure that all investors are looking for the same standards and that companies develop policies and measurement systems on those.

A framework thus requires criteria that are well-placed in science to provide recommendations that are backed up by research. As impact investing is an emerging market still under development, most of the literature dealing with the subject comes from practitioners (Daggers & Nicholls, 2016). The coverage of the concept in scholarly literature has been lagging (Agrawal & Hockerts, 2021; Yaşar, 2021) while most of the existing academic literature focusses on institutional and practical aspects from an investor's perspective. Few have analysed corporate biodiversity impact from an ecological perspective (Samkin et al., 2014). Investing in the forest sector has the additional challenge of having to deal with long time frames and uncertainty regarding future conditions (Lidskog & Sjödin, 2016). Trees take a long time to grow which poses a risk under changing conditions such as climate change, political shifts and market forces (Simmons et al., 2018; West et al., 2021). As such, a framework would benefit from both natural and social sciences to develop integrated recommendations. The framework should show how forest companies can establish and maintain resilient forests, thereby contributing to biodiversity conservation in the long run.

In short, it is clear that biodiversity levels are declining and action is urgently needed. Impact investments could contribute to mobilising financial resources necessary to take measures. However, it remains unclear if impact investing can live up to this expectation and make an overall net positive impact on biodiversity (Thompson, 2023). Therefore, this research outlines how investors can contribute to biodiversity conservation by investing in sustainable and resilient forestry while gaining financial returns. The acquired knowledge could aid in the mainstreaming of biodiversity and resilience thinking in impact investing while serving as an example for forest companies, projects or similar frameworks.

1.1 Research aim & questions

Given the several issues as outlined above, this research aims to aid in the mainstreaming of biodiversity in the impact investing narrative. It attempts to fill the gap that the absence of a tailored impact framework for the forest sector leaves. This research seeks to offer such framework that allows investors to evaluate biodiversity impact while not losing sight of social impacts and financial returns. The framework may encourage impact investors to set biodiversity targets and guide companies in their reporting. In the end, the framework was tested on two forestry companies (impact investments)

in Paraguay that will be further explained in chapter 3. The research is guided by the following research questions:

1. How can impact investments in the forest sector operationalise social-ecological resilience (SER) to create a positive impact on biodiversity?
    a. What major themes of SER operationalisation are present in the literature?
    b. What major themes regarding impact investments in the forest sector are present among experts related to the Dutch impact investing landscape?

2. How do the operationalisations of SER fit into an impact framework to assess impact investments in the forest sector?
    a. What are the indicators that make the identified themes (sub-questions 1a, 1b) measurable?

3. To what extent do two cases of impact investments in San Pedro, Paraguay match the impact framework?

2 Theoretical framework

This chapter starts with an elaboration on the concept of biodiversity in 2.1 to establish a common definition. In section 2.2, social-ecological systems thinking and resilience approach will be explained. The chapter finishes by providing the conceptual framework of this study (2.3).

2.1 Biodiversity

When discussing the mainstreaming of biodiversity in impact investing it is important to have a common understanding of 'biodiversity'. Biodiversity can mean different things to different people which can lead to confusion and misunderstanding (Bermudez & Lindemann-Matthies, 2020; Norton et al., 2021; Sarkar, 2016). This is especially relevant for investors claiming to have a reduced or even positive impact on biodiversity. What do they mean by this exactly? A commonly used definition of biodiversity is the one adopted by the Convention on Biological Diversity (CBD):

> *"Biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems"* (CBD, 2006).

In this definition, three aspects can be distinguished: (1) diversity within species, (2) between species, (3) within and between ecosystems. Each of these aspects requires attention in the case of biodiversity conservation. Sufficient genetic diversity within a species supports their conservation (DeWoody et al., 2021). However, current conservation approach are focussed more on species than their genetic diversity (Coates et al., 2018). Secondly, species diversity enhances ecosystem functioning (Cardinale et al., 2002; Pasari et al., 2013). Finally, a diversity of ecosystems and structural diversity within those ecosystems or habitats are necessary to provide sufficient habitats for species (Walter et al., 2021). Suitable abiotic and biotic conditions should be present for each species.

Biodiversity conservation means "the maintenance and recovery of viable populations of species in their natural surroundings" (CBD, 2006). In other words, the protection and restoration of natural ecosystems, species and their genetic diversity. This links to the goals of impact investing for biodiversity. In fact, the main objective of the ASN Biodiversity Fund is to contribute to "maintaining, protecting and restoring biodiversity" (ASN Impact Investors, 2022, p.1). This is no simple task given the many threats that forests and biodiversity are subject to today.

2.2 Social-Ecological Systems and Resilience

According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the main threats to biodiversity are habitat loss, overexploitation, invasive alien species, pollution and climate change (IPBES, 2019). These drivers of biodiversity loss can all directly or indirectly be linked to human action. Humans directly contribute to habitat loss through deforestation (Jayathilake et al., 2021). Overexploitation may be caused by unsustainable harvesting regimes and illegal logging or poaching. Other threats such as forest fires can be a combination of direct action exacerbated by indirect drivers like climate change. People burn forests to clear land for agriculture while forest fires may increase in frequency, intensity and expansion due to drier conditions as a result of a warmer climate. Despite these threats many people, mainly the world's poor, still depend on forests and biodiversity for their livelihoods (FAO & UNEP, 2020). Likewise, it has been estimated that more than half of global GDP depends on nature and biodiversity (WEF, 2020). This illustrates that human and natural systems are interlinked in so called social-ecological systems (SES). Ecology and society shape and are shaped by each other. SESs are characterised by their internal dynamics and strong relationships between ecological and social components. As such, the distinction "between social and natural systems becomes artificial and arbitrary" (Berkes & Folke, 1998, p.4). Even forests are not mere ecological systems operating in a vacuum. Forests are subject to management and the

wider societal dynamics of policy, economics and cultural changes. Policy and law steer management in a certain direction, economic conditions and markets affect demand for forest products while people can have different cultural approaches and views towards nature.

As such, forests are part of SESs (Swanson & Chapin III, 2009). Forest SESs are characterised by their long temporal feedbacks. Due to the longevity of trees, policy changes made today will affect future generations (Fischer, 2018). Given these long feedback loops and great uncertainty regarding future climatic and socioeconomic conditions, there is a need for resilient SESs. Many actors, with different relationships and feedback loops make up the state and management of forests. The focal systems of this study are hence forests as places that harbour biodiversity, with direct links to society (e.g. companies, managers, local communities). The SES surrounding forests will have to cope with changing circumstances in order to meaningfully contribute to biodiversity conservation.

While many of the current and future threats, as well as the uncertainty surrounding them, put pressure on SESs and biodiversity they may also constitute risks to investors. For example, forest fires are a threat for both; fires reduce the stock of (merchantable) timber and damage the ecosystem. As such, a social-ecological resilience approach can provide some valuable insights for investors looking to invest in forests and have a positive impact on biodiversity.

While this need for resilience is widely acknowledged, definitions and implementation strategies differ broadly. In general, resilience is defined as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker et al., 2004, p.2). Over time, resilience is variously used by different scholars and different resilience concepts have been developed. Most notably, engineering resilience, ecological resilience and social-ecological resilience. Engineering resilience assumes a single equilibrium state and deals with the time it takes for a variable to return to this stable state after disturbance (Pimm, 1984). Ecological resilience is defined as "a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling, 1973, p.14). Ecological resilience recognises multiple equilibria while a system can recover from disturbance or shift to a different equilibrium. Social-ecological resilience combines society and ecology into self-organising systems and focusses on their aggregated adaptive capacities (Folke, 2006). It is hard to regard many challenges, such as climate change, as purely ecological or social. Both ecology and society interact and find ways of dealing with change. In the case of climate change, many different people, plants and animals on a local to global scale are affected by it. So social-ecological resilience is here defined as "the capacity of a social-ecological system to absorb or withstand perturbations and other stressors such that the system remains within the same regime, essentially maintaining its structure and functions. It describes the degree to which the system is capable of self-organization, learning and adaptation" (Holling, 1973; Gunderson & Holling, 2002; Walker et al., 2004 cited in Resilience Alliance, n.d.). Social-ecological resilience is thus the ability of a SES to absorb disturbance, self-organise and adapt to changes (Folke, 2006). Rather than assuming multiple equilibria or stable states, it deals with 'adaptive cycles'. Leaving the idea of a stable state behind, emphasis has shifted to flexibility and learning ability (Li et al., 2020). So change is part and parcel of social-ecological systems while it is not considered inherently negative or positive (Sterk et al., 2017). In short, a social-ecological resilience approach does not explore if the system can absorb disturbances or *if* it will change. Rather, it is aware that the system *will* change and explores the dynamics at play that are shaping and shaped by the system (Rölfer et al., 2022).

Even though resilience is a popular concept throughout disciplines, it has sometimes been found challenging to operationalise due to different interpretations of the concept (Moser et al., 2019). Nikinmaa et al. (2020) have explored this in a forestry context and shown that common understanding of resilience and its operationalisation is lacking. Much of defining resilience revolves around formulating answers to the questions: resilience *of* what and *to* what? (Carpenter et al., 2001). What system is resilient against what disturbance and at which time scale? Rölfer et al. (2022) highlight the subjectivity of defining the system and norms regarding desired and undesired states. Different actors may have different answers to questions "*of what*, for *whom*, and *how* resilience occurs" (Beauchamp et al., 2020, p.2). Cote and Nightingale (2012, p.485) have also asked the question of "resilience for

whom and at what cost to which others?". They show that increasing social-ecological resilience is not necessarily beneficial or desirable for everyone and thus a normative undertaking.

Despite different conceptualisations of resilience, the following seven principles of resilience have been developed as a general guide to building resilience in SESs (Biggs et al., 2012; Sterk et al., 2017). These principles guided this study in selecting what forest companies/projects could do to increase their resilience, thereby serving the conservation of biodiversity and benefiting society:

1. Maintain diversity and redundancy
2. Manage connectivity
3. Manage slow variables and feedback
4. Foster complex adaptive systems (CAS) thinking
5. Encourage learning and experimentation
6. Broaden participation
7. Promote polycentric governance systems

Principle 1: Maintaining diversity and redundancy.
A diversity of elements within the system can lead to greater resilience as those elements may respond to disturbances differently (Aquilué et al., 2020). The elements that are better able to cope with a certain shock may thus be able to compensate for ones less able to do so, which is referred to as redundancy (Biggs et al., 2020). This does not only include a diversity of species but also a diversity of actors and institutions with different resources and expertise.

Principle 2: Manage connectivity
Connectivity allows for sharing and dispersal, whether this be of genes, seeds or information. Forest fragmentation is known to have adverse effect on forests and biodiversity (Ewers & Banks-Leite, 2013; Liu et al., 2019). So it is important to reduce this and connect habitats. It would also be beneficial to connect people and foster an exchange of knowledge. A challenge with high connectivity is that pests and plagues may spread more easily. It is therefore essential to manage connectivity whilst applying other guiding principles.

Principle 3: Manage slow variables and feedback
A key aspect of a SES approach is its focus on slow variables and feedbacks. These can be positively (increasing) or negatively (decreasing) reinforcing effects. Feedbacks occur when a change in a certain variable reinforces or reduces the same change. For example, clearing forests on a slope leads to some erosion. This in turn makes it more difficult for vegetation to re-establish leading to further erosion. Biodiversity can be part of a positive feedback loop. Higher levels of biodiversity make an ecosystem more resilient through the 'insurance effect' for example (Oliver et al., 2015). Insurance theory states that biodiversity can mitigate the effects of disturbances on ecosystem functioning as species differ in their response to disturbances (Loreau et al., 2021; Yachi & Loreau, 1999). Species that are better able to deal with change will compensate for other species less able to do so. This ecosystem is then better able to deal with stress and alleviate pressure on biodiversity. So these are two reinforcing elements that boost overall resilience.

Principle 4: Foster complex adaptive systems (CAS) thinking
Complex Adaptive Systems (CAS) thinking should be invited by the complexity and unpredictability of SESs. CAS are characterised by six features; they are relational, adaptive, dynamic, open, contextual and emergent (Preiser et al., 2018). Elements within a CAS are organised *relationally* where the interactions between elements is more important than the characteristics of each individual element (Preiser et al., 2018). The overall dynamics of the system is therefore determined by many interconnected elements where the system is more than the sum of its components (Biggs et al., 2021). The connections between elements are *adaptive*, meaning they change depending on the circumstances. This is characterised by decentralised self-reorganisation and ability to anticipate to a

changing environment. Such highly *dynamic* system has multiple (nonlinear) trajectories, crosse-scale interactions, thresholds tipping points and feedback loops (Preiser et al., 2018). Through these diverse and dynamic interactions, complex *emergent* behaviour should be expected. The large web and multiple pathways of causality can lead to unpredictable outcomes. The same starting positions are expected to produce different outcomes while small inputs can have large effects (Sellberg et al., 2021). As such, the system is highly *contextually* determined. When the context changes, the system will change as a consequence. Because the context and interactions are so important, CAS are considered radically *open*. It is hard to define which elements are inside the system and which ones are part of the broader environment. Any boundaries are also permeable allowing matter, energy and information to be exchanged.

Principle 5: Encourage learning and experimentation
Due to this complexity and in dealing with uncertainty, it is key to encourage learning and experimentation. Learning can be acquiring new knowledge or skills in partnership with for example scientists and stakeholders (Sterk et al., 2017). The current trends of climate change, population growth and globalisation may pose challenges currently unknown and without existing management solutions (Lindner et al., 2014). It will be up to the involved parties to ongoingly explore, learn and adapt.

Principle 6: Broaden participation
Participation facilitates the collective action necessary to tackle the biodiversity crisis as it will not be solved by only a handful of people or institutions (Jagers et al., 2020). Involvement of different stakeholder and organisations can enable knowledge sharing, cooperation and the building of trust (Sterling et al., 2017).

Principle 7: Promote polycentric governance systems
Polycentric governance systems can serve as the platform on which the principles of learning, participation, connectivity and diversity play out. A polycentric governance system is one “in which there are multiple interacting governance bodies with autonomy to make and enforce rules within a specific policy arena and geography” (Schoon et al., 2015, P.226). Here, governing bodies interact with each other, both horizontally and vertically. This allows governing bodies to self-organise while finding a balance between autonomy and collaboration. A key aspect are cross-scale dynamics within a polycentric governance system (Ostrom, 2010). This refers to multiple decisions made at different scales. For example, decisions surrounding a large water body should be made at the watershed council while issues involving local farmers can be made at the village level or municipality.

2.3 Conceptual framework

As explained in the problem statement (Chapter 1) there is a need for an impact framework applicable to the forest sector. Slootweg (2005) has already developed a preliminary biodiversity framework while he indicated that this needed further experimentation and refinement. This framework focusses on understanding and measuring the biodiversity impact of an activity. Later, Addison et al. (2020) have provided a step-by-step approach for companies to assess their biodiversity performance and set measurable objectives. Building upon this, in a publication by the International Union for Conservation of Nature (IUCN), Stephenson & Carbone (2021) have developed another method of monitoring biodiversity impact in a corporate context. An important step in the latter two publications is the formulation of objectives or criteria that are linked to measurable indicators. These criteria and indicators help to guide how companies can reduce their impact or even create positive impact on biodiversity. Kennedy et al. (2022) argue that biodiversity impact measurement can greatly benefit from a resilience approach. Therefore, the idea of criteria and indicators was combined with the SES resilience principles in an impact investing context which resulted in the conceptual framework below (Figure 2). The structure of principles, criteria and indicators is also familiar to forest managers as it is

used in management plans (Larrubia et al., 2017) and certification standards such as the Forest Stewardship Council (FSC) standard. Similarly, investors use the term Key Performance Indicators (KPIs) when referring to measurable indicators that track the performance of investments.

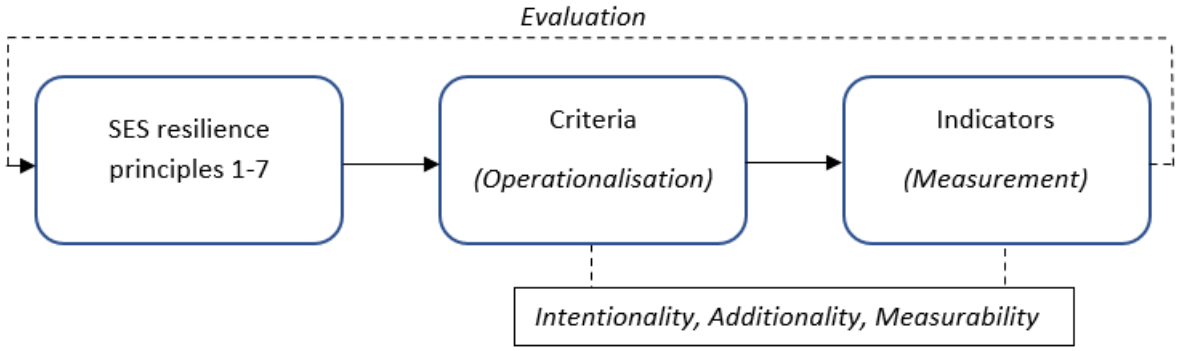

Figure 2: Conceptual framework. This study is guided by seven social-ecological (SES) resilience principles. Criteria show how these principles are operationalised. Indicators make these criteria more specific or measurable in the forest/impact investment context. Criteria and indicators also show how impact investments contain the characteristics of intentionality, additionality and measurability. Through ongoing learning and evaluation, the criteria and indicators can be adjusted or new ones added.

This conceptual framework guided this study. The social-ecological resilience principles helped defining how 'positive impact' can be made. To make the seven principles more practical in the forest context, criteria were identified. Criteria are what a forest company/project should aim for (intentionality). These criteria outline how additionality in impact investing can be created as such criteria may be absent in traditional investing. To make criteria specific and measurable, indicators were formulated. Subsequently, these principles, criteria and indicators were combined in a framework. Finally, the framework was implemented and tested on two forest companies and adjusted accordingly. Based on this framework, investors can evaluate company policy. Forest companies or funds, in turn, can adjust their policy and reporting according to the framework.

3 Methods

Four general steps within this research can be distinguished (Figure 3). The first two are a literature survey and interviews, that were conducted simultaneously. These provided the results that served as the foundation of the impact framework. In the third step, the actual impact framework was developed. This impact framework was subsequently used in a trial assessment of two cases of impact investments.

This chapter first explains the general study design or methodology (3.1). This is followed by an explanation of the data collection process and introduction to two real-life cases of impact investments in the forest sector (3.2). Section 3.3 explains how the obtained data was analysed and translated to the impact framework and how this was subsequently tested on the cases.

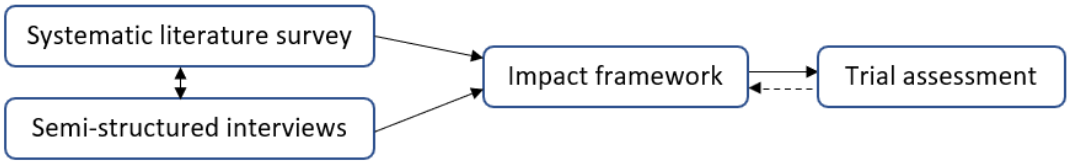

Figure 3: General overview over the different methods employed in this study. A systematic literature survey and semi-structured interviews provided the criteria and indicators that are included in the impact framework. This framework was then used in a trial assessment of two forestry companies that provided some feedback on the impact framework.

3.1 Methodology

This research project followed a multimethod research approach. Multimethod research uses multiple forms of qualitative data or multiple forms of quantitative data (Creswell, 2015). In other words, it involves a combination of different qualitative or quantitative methods in a single study. This often leads to some confusion with the term 'mixed methods' (O'Reilly et al., 2021). However, mixed methods generally refers to research that combines quantitative *and* qualitative methods while multimethod research uses methods within the quantitative *or* qualitative paradigms (Anguera et al., 2018; Schoonenboom & Johnson, 2017). Here, the multimethod research approach is used by combining two separate methods where the findings from both methods are later incorporated to answer the research questions (Morse, 2010). The two datasets obtained for this study (literature and interviews) complemented each other as one would not provide the desired outcomes without the other.

One of the methods is a systematic literature survey into social-ecological resilience that was carried out to provide the scientific input for the impact framework. This addressed the need to explore the scientific backing for the criteria in the framework. In parallel, expert interviews were conducted that provided first-hand experience from people working in the impact investing and forestry industries. The two datasets supplemented each other as scientific literature lacks the required coverage of impact investments in the forest sector. On the other hand, people working in the financial sector who are looking to invest in forestry often suffer from a lack of scientific basis on how to select investees i.e. the characteristics of investments that contribute to resilience and biodiversity conservation.

ASN Impact Investors

Prior to the start of this research project, the researcher had been in contact ASN Impact Investors. This helped the researcher in identifying real-life projects/impact investments while simultaneously opening up contact with associated organisations. In the end, a contract between the researcher and ASN Impact Investors was signed that made it possible to share confidential documents or information, either from ASN Impact Investors or the companies taken as example cases of impact investments. This way, the researcher gained access to data regarding investment funds/companies (such as policy documents) that is not publicly available but still of value to this study. At the same time, it granted

the researcher with valuable insights into how an impact investor operates, specifically into the due diligence process.

3.2 Data collection

This section first explains the data collection processes of the systematic literature survey (3.2.1) and expert interviews (3.2.2). Next, the cases of impact investments that were used in the trial assessment are introduced and the collection of data on those cases is explained (3.2.3).

3.2.1 Literature survey

A desk study was conducted that consisted of a systematic literature survey into social-ecological resilience. The inquired literature included peer-reviewed articles and book chapters. The figure below (Figure 4) shows the search and selection process of the literature. This process was based on the method used by González-Quintero and Avila-Foucat (2019). Their search included literature from 2005 to the start of 2017. Therefore, articles from 2017 onwards were included in the present study to find new papers that were published after the study of González-Quintero and Avila-Foucat. The final date of publication to be included in the database was October 20th, 2022.

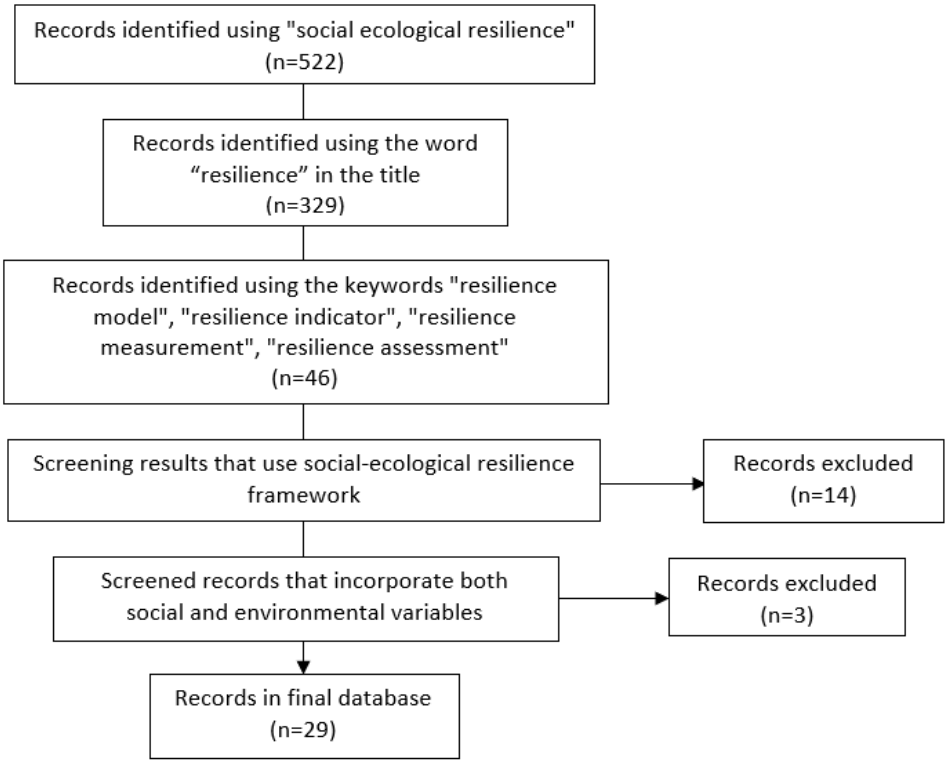

Figure 4: Selection process of the systematic literature survey. Based on González-Quintero and Avila-Foucat (2019).

First, databases were searched to find publications. González-Quintero and Avila-Foucat used the Web of Science (WoS) and Google Scholar databases. However, contrary to their method, Google Scholar was not used for the present study. Google Scholar has limited filter options, making a systematic search more complicated and time consuming. Gusenbauer & Haddaway (2020) also point towards the unsuitabiltiy of Google Scholar as the primary source for a systematic literature survey. They show that Google Scholar produces different results over multiple searches providing non-reproducible results. Therefore, the Scopus database was used instead and in addition to Web of Science (WoS). Scopus and WoS do not have the shortcomings that Google Scholar has and are shown to be suitable as primary sources for a systematic literature survey (Gusenbauer & Haddaway, 2020).

The filter options between both databases differ slightly, so the search string TITLE-ABS-KEY ("social ecological resilience") was used for Scopus and TOPIC ("social ecological resilience") was used for WoS. Only publications in English were included.

Second, TITLE (resilience) was added to both databases to filter out records that use resilience in the title. González-Quintero and Avila-Foucat (2019) mention that many papers have the word "resilience" somewhere in the text while often resilience is not part of the scope of the paper. So the use of the word resilience in the title was intended to select publications where resilience was part of the scope.

Third, +ALL ("resilience model" OR "resilience indicator" OR "resilience measurement" OR "resilience assessment") was added to include records that show how resilience is operationalised or measured.

Fourth, the remaining records were screened by reading titles and removing some of the publications that were found in both databases (duplicates). Only unique records were included in the final database. The article by González-Quintero and Avila-Foucat (2019) was also removed from search results.

Fifth, records were screened by skimming through the text to exclude the ones that did not use a social-ecological resilience framework. Such publications were for example centred around personal health, well-being and psychology. Others discussed social-ecological resilience but did not employ this approach in their analysis.

Sixth, records were evaluated in-depth and the ones that did not incorporate both social and environmental variables were excluded. As the nature of the social-ecological resilience approach blurs the boundaries between social and environmental variables, they cannot be considered independently. In the end, this resulted in a final database of 29 publications. A list of the final database is included in appendix A.

3.2.2 Interviews

In parallel with the systematic literature survey, expert interviews were conducted. The interviews serve as triangulation of the themes found in literature and to gain additional information (Bogner et al., 2018; Von Bary et al., 2018). Experts have ideas, thoughts or experiences that have not been published but are still of value (Meuser & Nagel, 2009; Von Soest, 2022). Since impact investing is a topic that has not been studied extensively by scholars (especially outside the accounting discipline), data was gathered from practitioners in the fields of impact investing and/or forest projects. Therefore the literature served as a more general inquiry into how social-ecological resilience is operationalised, while the interviews provided more insight into how this plays out in the context of impact investing in the forest sector.

The scope of this research was narrowed to the Dutch impact investing landscape to make research sufficiently focussed. Countries or regions (like the EU) have different regulations that may lead to different views on and implementation of impact investing. Since the Netherlands contains a relatively large impact investing market (Eurosif, 2018; Wessemius-Chibrac et al., 2022) it serves as an excellent field for this study. The respondents were selected using a purpose sampling strategy (Etikan et al., 2016) in combination with snowball sampling. Interviewees were screened on relevance to specific knowledge (i.e. regarding impact investing, forest project development, fund management) and their position or background, for example the organization they have worked at previously (Döringer, 2021). To start off the selection process, members lists of the Global Impact Investing Network (GIIN), Partnership for Biodiversity Accounting Financials (PBAF) and Finance for Biodiversity Pledge were searched using a set number of criteria. One, investors had to be based in the Netherlands. Two, impact investing had to be mentioned explicitly as (part of) their strategy or investors should manage Sustainable Finance Disclosure Regulation (SFDR) article 9 funds. Three, investors should invest in forests. To find consultancies working with investments in forests or investment funds, the entries "Forest consultancy Netherlands" and "forest* investment fund Netherlands" (in English) were put in the Google search engine (search date: September 8, 2022). These searches were also attempted in Dutch but that did not provide the desired results. Similarly,

no forest investment funds in the Netherlands were found so, for that, the scope was extended to funds in Europe. Dutch impact investors looking to invest in forestry companies would also be led to these funds as was confirmed through communication with ASN Impact Investors. In addition to the search online, the professional network of members at ASN Bank and ASN Impact Investors was used through a snowball sampling approach as they had already been in contact with many external organisations and experts. Their acquaintance with some of the experts also facilitated making contact between the researcher and the experts.

The number of interviews was subject to time restrictions and availability of respondents but 11 people were contacted through e-mail. In case of non-respondence they were contacted by phone or a reminder was sent via e-mail. In the end, 8 interviews with 9 interviewees were conducted (see appendix B for a list of interview organisations). The interview with ASN Bank and ASN Impact Investors was combined for convenience and because the organisations are closely linked, the interviewees could complement each other during the interview. Although the number of interviews is not exhaustive it should cover many of the existing themes (Francis et al., 2010; Guest et al., 2006; Namey et al., 2016). The selected and contacted experts who were willing to participate were interviewed online through video calls in MS Teams. Video calls have emerged as the standard way to meet people after the Covid-19 pandemic (de Villiers et al., 2022). They are a convenient and generally accepted, or even assumed way, to have meetings. Interviews were recorded for accuracy of data collection by not trusting on human memory and to supplement notetaking (Russel, 2017). Prior to each interview, the interviewee was asked for consent on recording of the interview. Additionally, individual anonymity was guaranteed. Interviewees were also informed about the purpose of the study in the contact e-mail and at the start of the interview.

Each interview followed a semi-structured interview approach to take advantage of the directive yet open nature of the technique. Semi-structured approach means that certain topics are covered in each interview while allowing for free input by the interviewee (Adams, 2015). As such, semi-structured interviews allow for comparison while experts can provide additional insights they deem relevant. The topic list and guiding interview questions that were used during the interviews are included in appendix C. Interviewees were asked about aspects of impact investing (in general or in forestry specifically) that were not covered in literature. This mainly allowed to go into how intentionality, additionality and measurability play out in practice and how practitioners deal with the associated challenges of forest project development/investments.

3.2.3 Example cases of impact investments

As already mentioned in the problem statement, ASN Impact Investors is a leading impact investor in the Netherlands, explicitly targeting biodiversity. They currently have about EUR 4.0 billion in assets under management (as of June 2022; ASN Impact Investors, n.d.). ASN Impact Investors states that its Biodiversity Fund is the first in Europe that allows retail investors to directly invest in projects that have a positive impact on biodiversity. This makes their investments and screening processes an interesting starting point for the scope of this study. A potential receiver of funding from the ASN Biodiversity Fund would be the Arbaro Fund which aims to invest in sustainable forestry projects in Sub-Saharan Africa and Latin America. Other (impact) investors such as the Dutch Entrepreneurial Development Bank (FMO) and Green Climate Fund (GCF) have already invested in the Arbaro Fund (FMO, n.d.; GCF, n.d.). The Arbaro Fund was initiated in 2018 and has a size of about USD 111 million with about USD 38.5 million currently invested (Arbaro Advisors, 2022). The Arbaro Fund is managed by Finance in Motion, an impact asset manager based in Germany that has invested a total of about USD 6 billion to date (Finance in Motion, n.d.). Arbaro Advisors acts as the investment advisor to the Arbaro Fund. Their role is to offer advice on the selection and development of investments. Arbaro Advisors was established by Finance in Motion and the UNIQUE Group. The UNIQUE Group offers consultancy services in forestry and agriculture and through their sister company, Unique forest investment, they also manage about 20,000 ha of production forest in Paraguay (Unique forest investment, n.d.).

At the start of this study, the Arbaro Fund had been invested in three forest companies. Two of these companies, Forestal Apepú and Forestal San Pedro, are located in Paraguay. The third is Miro

Forestry which operates plantations in Ghana and Sierra Leone. The Arbaro Fund has been invested in Forestal Apepú since 2019 and Forestal San Pedro since 2021. These two plantation forestry companies served as the real-life cases on which the impact framework was tested. They were selected as trial cases because the researcher was granted access to information on these companies through contact with ASN Impact Investors and Arbaro Advisors. Moreover, both companies are fully owned by the Arbaro Fund, meaning no other organisations had to be involved and give permission on disclosure of information. In addition, Unique forest investment is involved in the management of Forestal Apepú and Forestal San Pedro (Unique forest investment, n.d.) facilitating access to both companies' management. During the course of this study, the Arbaro Fund has increased its investments to a total of six forest companies in Latin America and Western Africa (Arbaro Advisors, n.d.).

Forestal Apepú and Forestal San Pedro both manage forests in several different places throughout the San Pedro region (Figure 5). The ecoregions in San Pedro are classed as humid Chaco in the west and Atlantic forest in the east (Huang et al., 2009). San Pedro has a total area of about 20,880 km^2 with forests covering about 4,354 km^2 (20.8%) in the 2000s (Huang et al., 2009). This was a decrease in forest cover of about 31% since the 1990s. Between 2001 and 2021 the department of San Pedro experienced a further decrease in tree cover (Global Forest Watch, n.d.).

Documentation on the cases in relation to the framework was received from Arbaro Advisors. This included Environmental and Social Impact Assessments (ESIA) for Forestal San Pedro (GEOCONSULTORES, 2020) and Forestal Apepú (Arbaro Advisors, 2021) and the Environmental and Social Management System (ESMS) from the Arbaro Fund. The most recent version of the ESMS (dated June 3, 2022) was used for the analysis but is not publicly available. A previous version from August 2019 is available online (Arbaro Fund, 2019). Additionally, online information such as an annual sustainability report (Arbaro Advisors, 2022), public versions of the companies' management plans (UNIQUE, 2021, 2022) and Youtube videos (Unique land use, 2022) were inquired.

Figure 5: Maps showing the locations of Paraguay (left) and the San Pedro region (middle), both highlighted in red. The map on the right indicates the locations of the forests managed by San Pedro (red dots) and Forestal Apepú (blue dot). Adapted from Wikimedia Commons (2011a, 2011b) and (GEOCONSULTORES, 2020).

Given the severe pressure on natural forests and high demand for wood products globally, plantations are often seen as a necessary alternative to meet this demand (McEwan et al., 2020). Plantations have also been recognised as providing benefits to biodiversity (Brockerhoff et al., 2008), for example through climate change mitigation and adaptation (Pawson et al., 2013). It is therefore understandable that impact investors follow this line of thinking and invest in plantation companies such as the ones presented here.

3.3 Data analysis

The analyses of the interviews and literature followed different approaches. First the interview analysis will be covered in this section (3.3.1), followed by the literature analysis (3.3.2). After that, it is

explained how the impact framework was developed (3.3.3). Finally, the process of how the framework was tested on two cases of impact investments (forestry companies) is explained (3.3.4).

3.3.1 Interviews analysis

The data obtained through the interviews was analysed using a thematic analysis following Braun & Clarke's (2012) approach. Thematic analysis is a way to identify themes within qualitative data and to interpret those themes while being guided by a topic or question (Clarke & Braun, 2016). A benefit of thematic analysis is that it can reveal clearly stated and more implicit contents across datasets (Joffe, 2011). Braun and Clarke propose six phases in their method: 1) Familiarizing yourself with the data; 2) Generating initial codes; 3) Searching for themes; 4) Reviewing potential themes; 5) Defining and naming themes; 6) Producing the report.

In the first step, interviews were transcriped. This was done ortographically, including sounds like 'umm' or unfinished words like manageme- (for management) as it shows 'how' somebody said it. Depending on the interviewee and language used during the interview the transcript was in Dutch or English. During transcribing and reading through the transcripts, the author took notes of general thoughts arising in the mind to get a better feeling of the data. These notes also served as inspiration for the codes.

The second step involved reading through the transcripts and generating codes (in English) using ATLAS.ti (Version 22.0.6.0) software. Codes related to anything that seemed relevant for answering the research questions. If it seemed relevant, it was coded. Interpreting texts and coding is not a completely 'neutral or objective' activity but is influenced by the knowledge and background of the researcher. To provide some information on the researcher, a short description of academic and personal experience is included in appendix D. After going through all transcripts the codes were reviewed. For example 'threatened species' and 'endangered species' were combined as they carried the same meaning in the interviews. Likewise, native species and indigenous species were combined. In other cases, singular and plural were combined like the case of NTFP and NTFPs.

Step three meant reading through the generated codes and additional notes to search for overlap between codes. Any pattern in the codes that could be an answer to the research question was written down as potential theme.

Step four revolved around checking the themes with the dataset. Some potential themes could be considered as part of a more overarching theme and where thus combined. It was checked again whether these themes related to the data and were not contradictory in some cases. Themes were also evaluated and judged to be specific enough in relation to the dataset.

In step five, it was explained why the final themes are so important and relevant for answering the research question. The themes were also given their final name, which consisted of a quote that captures it meaning in a single sentence to speak in the words of the interviewees.

The final step (six) was producing the impact framework and writing this report. The identified themes served as main inspiration for the later developed impact framework. On the development of the impact framework is further elaborated in sub-section 3.3.3 (next page).

3.3.2 Literature analysis

In line with the data collection, analysis of the gathered literature was also based on the method used by González-Quintero and Avila-Foucat (2019). Even though González-Quintero and Avila-Foucat used five categories for their analysis, only three were used here. The other two excluded categories contain the system variables and the approaches used to evaluate resilience i.e. models or indicators. Due to the broad range of settings in the papers (e.g. urban, agricultural and coastal areas), most variables were not applicable to forest landscapes or necessary for developing the framework. Similarly, since the present study focusses on criteria and indicators, a wider exploration of whether authors used models or indicators was deemed outside the scope of this study. The other three categories were considered suitable for the objective of this study and in answering the research question. The first of these three categories refers to the conceptual elements through which the concept of resilience is

operationalised. The second deals with the operationalisation of the seven resilience principles as introduced in section 2.2. The third describes which shocks and stressors were identified in the literature and are the answers to the question: resilience against what?

The selected papers were read in-depth and aspects relating to the conceptualisation of resilience, operationalisation of the SER principles or shocks and stressors were collected in an Excel database. Some variables related to multiple principles and, as such, were included in more categories. For example, 'participatory monitoring' was included in 'broaden participation' and 'encourage learning and experimentation' as it not exclusively related to either one of those. Some basic statistical analysis was done to gain the total number of entries and coverage in publications per category. Whereas González-Quintero & Avila-Foucat (2019) conducted a purely quantitative analysis of the data, the present study also includes a qualitative analysis. The identified operationalisations were considered much like codes in the interviews and dominant themes were identified from these. The themes were linked to the SES resilience principles as these are the theoretical foundation for the themes. This means that the results from the literature survey were analysed using a more deductive approach with the seven resilience principles in mind. These principles served as the 'filter' for identifying relevant themes in the literature results. So only the emerging themes that are an operationalisations of the SES resilience principles were included to answer the research question (1a).

3.3.3 Developing the impact framework

Developing the framework involved translating the findings from the literature survey and interviews to practical criteria and indicators. As a first step, the main themes identified in the literature were taken as the criteria in the framework. These criteria thus represent recommendations of how to operationalise the social-ecological resilience principles. Additional, but critical, findings from the interviews supplemented the literature to complete the list of criteria. Several important considerations were identified in the interview transcripts that were not adequately covered by the literature. Still, these were deemed key to implementation of the framework in the context of investments in the forest sector.

Linked to the criteria, are the indicators that can be applied in the specific context and make the criteria measurable. The datasets were enquired again to find one or multiple indicators for each respective criterium. With specific criteria in mind, the researcher went back through the codes and variables from the literature to find associated indicators. For some criteria, there were suitable indicators present among the resilience variables in the literature. For example, the criterium of 'social connectivity' was addressed in the literature by measuring social capital. Social capital assessments were thus included as the indicator corresponding to the social connectivity criterium. However, most of the indicators were extracted from the interviews as these turned out to be more applicable to impact investment and forestry contexts. The researcher selected a code that was relevant to a criterium and evaluated the transcripts. For example, the criterium 'monitoring' had a code about monitoring corresponding to it. In the coded excerpts from the transcripts people mentioned what they monitored or would like to (be) monitored specifically. These examples led to a short list of potential indicators that could be combined or further refined based on practical application. These indicators were also checked against the wider literature to ensure sufficient scientific support.

Overall, developing the impact framework proved to be a pragmatic exercise. Mainly due to the intended use of the framework as a practical tool, both for investors as for investees. An investor needs to be able to use the framework as a relatively simple and time-efficient list of criteria and indicators on which to evaluate a potential investment. So each indicator needs to be captured by a single value or small description to show something is included in company/fund policy. An investee (forest manager) needs to be able to implement the requirements set in the framework and be able to report on those. In the end, a preliminary version of the impact framework was drafted based on the seven SER principles with corresponding criteria and indicators. Finalising the impact framework happened through an iterative process that involved moving between data, literature and practice.

3.3.4 Testing the impact framework

The purpose of the assessment of real-life cases is to test the framework in practice and show where the framework and impact investments do not align. This could be twofold. One, there could be no data from the fund or company on the respective indicator. Two, the data does not meet the level or quality as required by the indicator. Identifying these gaps highlights the points for improvement, either on the reporting side or actual practices of the companies.

Before delving into the assessment, the draft impact framework was brought to a group discussion with several members of ASN Bank and ASN Impact Investors after which written feedback was received as well. By incorporating the received feedback, the draft was further refined to make it more tailored to the use of investors and implementable in practice. Any adjustments made in consequence of the feedback were textual changes to improve the general clarity and level of detail.

The resulting impact framework was subsequently tested in an assessment of two forestry companies. To familiarise the researcher with the companies, two online meetings were held; one with Arbaro Advisors and another with Unique forest investment. During the meetings, the contact person at each organisation provided background information on the companies/cases. This combination provided perspectives from the fund level (Arbaro Advisors) as well as on-the-ground management (Unique forest investment). After analysis of the cases using the acquired documents, written feedback was obtained from Unique forest invest to check the findings and gain additional information.

4 Results

This chapter presents the results and answers to the first research question and sub-questions (1a, 1b). These results serve as the foundation for the impact framework in the following chapter (5). First, the main themes from the expert interviews are presented to provide an understanding of the situation in which the framework is positioned i.e. impact investing in the forest sector. Especially, since the framework is intended for practical use, some practical insights from experts enhances understanding of what practitioners are dealing with.

4.1 Impact investing in the forest sector

Two main themes regarding impact investing in the forest sector were identified in the interviews. These themes capture the main considerations regarding impact investments in the forest sector. These findings are not (always) directly incorporated in the framework, rather they shape the context in which it is applied. Each of these themes is discussed below.

4.1.1 "That's why certification is so important"

Certification is featured throughout all interviews. The main reason being that certification is regarded as an easily identifiable way to assess the sustainability of forest management. In all instances, investors require some type of certification. Some common ones for timber producing forests are FSC, PEFC and SFI, with FSC being the most dominant one. Interviewees mentioned: "We have never done anything without FSC" (Independent consultant, personal communication, October 4, 2022), "FSC certified, would be an advantage, or in fact a requirement" (ASN II, personal communication, September 9, 2022). Certificates cover many of the aspects that impact investors may look for in forests. This saves an investor a lot of time in the due diligence process as the investor does not have to screen a potential investment on the criteria himself. Those criteria are already guaranteed by the certification standard. At the same time certification standards still allow the investor to set additional criteria if wanted. Moreover, a combination of different certification standards can be applied in a single project. For example, if any forest projects includes agricultural production, standards such as Rainforest Alliance could be opted for.

In the case of carbon credits, examples certification standards include the Verra Verified Carbon Standard (VCS) and Gold Standard. Carbon certification benefits a project by providing credibility about sequestration and while a certificate could allow the seller to ask a higher price for a credit. ".. you provide insight into your social and biodiversity impacts with the idea that you will get a higher price for a carbon credit." (Treevive, personal communication, October 13, 2022). Besides the potential for a higher price, it can also increase credibility. Credibility is assured by third-party verification or audits that objectively assess a forest project. This is very important for investors as it reduces the reputational risk. Certification shows that you care about sustainability and have done something towards achieving that.

Another benefit to certification is the requirement for periodic monitoring. Certification schemes often require the certificate holder to monitor its activities. This improves long-term success of the project. For example, a project that plants a lot of trees in a short amount of time could be framed as a success. However, if none or very few trees remain alive for the subsequent years, it would be classed as failure. As one interviewee put it: "and if it is certified, it still occurs, but then, then at some point it will come to surface in a certified forest. Because then you have to monitor. Yes, and then you will realise you don't have the results." (Face the Future, personal communication, October 25, 2022). So certification is not a guarantee but seems to be an increase in chances of success.

With respect to monitoring and measurability, interviewees note that there is variety in complexity and methodology depending on what is certified. For example, protection a forest does only lead to avoided deforestation if the forest would disappear in absence of protection. Proving this is easier said than done, as you can never get an accurate projection of what would have happened. In other words, there is no counterfactual.

In some interviews, the idea of biodiversity credits was brought up even though interviewees do no currently use them. Biodiversity credits work similar to carbon credits, where someone who protects a unit of biodiversity gets paid through sales of the 'credit' by someone else interested in doing so. This adds to complexity even further as there is no standard definition, let alone measuring method and defined 'unit' for biodiversity. At least carbon or CO_2 can be quantified and is universal. A ton of CO_2 is a ton of CO_2, no matter where around the world it is. Biodiversity, on the other hand, differs widely across the world in terms of species, ecosystems and genetic material.

4.1.2 "There are different motivations which can be seen on a spectrum between impact, and return, and risk."

The second major theme in the interviews revolves around balancing risk, return and impact. Risk/return ratio is one of the key aspects of investing. An investor is usually only willing to take on a higher risk for a higher return. With impact investing, impact becomes part of that equation (Figure 6).

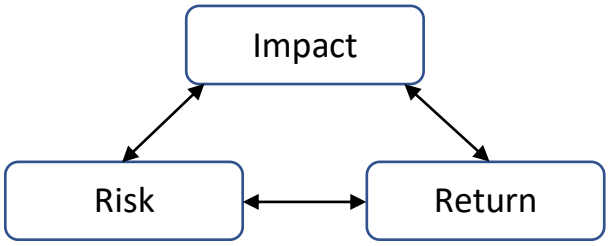

Figure 6: Three key aspects for impact investors. Each investor has to decide on the level of risk, returns or impact he is willing to take or accept.

Since the goal in impact investing is not only to create a financial return but a positive impact as well. The challenge is deciding on how much impact you want to create as an investor and what the minimum return is you are willing to accept. In general it could be stated that by demanding a lower return, an investor can have a larger impact. Protecting a forest should not be viewed as an opportunity cost that reduces returns, rather it is should be seen as a way to create impact. Another way is to use some of the returns that would normally be paid to investors for restoration efforts or example. It could also be stated that by taking more risk, an investor can make more impact. Investing in 'high risk' places where other investors do not dare to go can be a way to create additionality. Simply because without the impact investor, little or no money would go to that place to create impact. In the end, the exact balance between risk, impact and returns depend on the investor. Each investor has a different appetite for those, as one of the interviewees illustrated:

> *"There's ones [investors] that want the biodiversity sort of dealt with and responsible approach to biodiversity and managing environmental impacts and risks and things like that. That's one group, which is the probably the largest group investors, like the large institutions, pension funds and so on. And then you've got a second group, which tends to be high net worth individuals, family offices, who want our deep green and care more about the environmental impact .." (SLM Partners, personal communication, October 7, 2022)*

In the end, no matter how much impact you want to create, financial returns are the cornerstone of investing. However, an impact investor should look beyond this and also consider social or environmental 'returns'. One interviewee compared ESG investing to impact investing and said "I think that the most important difference is that it [impact investing] is much more focussed on positive impact." (ASN II, personal communication, September 9, 2022). ESG investing was understood here as exclusion of negative impacts. So rather than excluding negative impact, impact investors aim to create positive impact.

Besides deciding on *how much* impact, there are the questions of *what* impact and *how* will it be achieved? Interviewees talked mainly about decisions regarding forest management. Important aspects are harvest regime and regeneration method. There is generally a positive attitude towards selective logging systems while clear felling seems to be acceptable in plantations only. At the same time, the use of natural regeneration is supported. However, some people raise doubt about the feasibility of it in all instances (Form International, personal communication, October 12, 2022). For example, when grasses and lianas suppress naturally regenerated trees.

4.2 Criteria & indicators

This section revolves around the operationalisation of SES resilience. The results presented here can be interpreted as guidance on *how* SESs can be made more resilient. The identified themes (Table 1) serve as the criteria in the impact framework (Chapter 5). As discussed in the methods (Chapter 3), some criteria from the literature do not cover all aspects that are important to impact investments in the forest sector. Four additional criteria were derived from the interviews that supplemented the criteria obtained from the literature. These are: 1) Climate change mitigation; 2) Ecological connectivity; 3) Manage for diversity; 4) Benefit sharing. Below, the criteria are explained and the rationale for associated indicators is provided.

Table 1: Some examples of operationalisation of SES resilience in the literature and the themes derived from them. The table also shows the total number of entries per SES resilience principle (n) and the percentage of publications that operationalised the respective principle in one way or another (%). A complete list of all entries is included in Appendix E. Themes in italics are derived from the interviews, others from the literature.

SES resilience principles	Examples of operationalisation in the literature	Main themes (criteria)
Maintain diversity and redundancy	nurturing diversity, biodiversification, conservation activities, establishing protected areas, biological diversity, ecological variability (n=45; 41%)	• Biological/ecological diversity • Economic diversity • *Manage for diversity*
Manage connectivity	facilitating dialogue and building networks between different actors, social capital, relationships, marketing, cross-scale linkages, bridge differences in terminology, social network and support (n=33; 52%)	• Social connectivity • Institutional connectivity • Infrastructural connectivity • *Ecological connectivity*
Manage slow variables and feedback	understanding feedbacks between social and ecological processes, ecosystem-based approaches, considering potential thresholds of concern and possible regime shifts, explore underlying causes of shocks, consider historic context, identifying external drivers of change and interactions across scales (n=27; 48%)	• Understand underlying/ historical drivers of change • Climate change mitigation • *Risk management*
Foster complex adaptive systems thinking	living with change and uncertainty, adaptive management approach, highlighting and conceptualizing connections between people and the biosphere, acknowledging slow variables, identifying system components and their relationships (n=32; 59%)	• Adaptivity • Acknowledging change and uncertainty
Encourage learning and experimentation	willing to learn, knowledge sharing, combining types of knowledge, building a	• Monitoring • Integrating knowledge • Experimentation/innovation

	learning culture, experimentation, monitoring and learning (n=40; 59%)	
Broaden participation	local participation, stakeholder participation, enabling the creation of (multiple and/or shared) narratives, participatory stakeholder mapping, establishing a common vision, collective action, participatory goal setting (n=45; 45%)	• Participatory approaches • *Benefit sharing*
Promote polycentric governance systems	balance short-term and long-term measures, defining scale and boundaries for dealing with issues, navigating between stability vs transformability (n=32; 48%)	• Spatial scale • Temporal scale • Multi-scalar governance

4.2.1 Maintain diversity and redundancy

Within the principle of maintaining diversity and redundancy, two main themes regarding diversity were identified in the literature: biological diversity and economic diversity. Biological diversity refers to aspects such as different ecosystems, habitats and species. Economic diversity refers to aspects like the diversity of products, markets and income streams. In addition, experts discussed a variety of management systems/practices that could be used to support biodiversity. Since this topic was covered in all interviews and key to forest management, it was included as the third criteria to the principle of maintain diversity and redundancy.

Maintain biological diversity

The bottom line of this category is to maintain and restore biodiversity. An example is biodiversification or adopting different crop species instead of one (Panpakdee & Limnirankul, 2018). Another can be conservation efforts such as establishing protected areas and controlling invasive species. Before a manager can think of ways to maintain diversity, he/she needs to be aware of *what* and *where*. You cannot manage what you do not know. As such, an inventory of habitats and species is necessary. The high conservation value (HCV) approach and IFC Performance Standards were often referred to by interviewees. Therefore these were incorporated in the indicators as a way to identify and protect habitats. This would have to be combined with flora and fauna inventories to gain insight into the specific species that are present in any given area (Treevive, personal communication, October 13, 2022). Disclosing inventory results based on well-known lists such as the IUCN Red List and CITES appendix II could highlight the significance of the area and the species that require special attention (ASN Impact Investors, personal communication, September 21, 2022).

Investors can also align with other initiatives or targets. The post-2020 GBF now includes the 30 by 30 target which aims to protect 30% of the planet by 2030 (Zeng et al., 2022). The need to include private lands is now also being recognised as key to achieving this target (Saunders et al., 2023), highlighting the role that forest companies can play. Forest managers can adopt this target and dedicate 30% of their management area to conservation. In case there is currently less forest cover on their area under management or forests are severely degraded, managers can gradually work towards that 30% and opt for reforestation or restoration activities (Cerullo & Edwards, 2019). Such activities can be guided by standards like the International Principles & Standards for the Practice of Ecological Restoration (Gann et al., 2019). Restoration and protection of different habitat types could also be linked to the principle of managing connectivity (Fischer et al., 2006; Pomoim et al., 2022). For example, forests along streams and riparian areas are often protected and connect different parts of the landscape (Kuglerová et al., 2014). These wet places are often also more difficult/unsuitable areas for forestry and thus provide excellent opportunity for conservation and to increase habitat connectivity. However, as one interviewee mentioned, the additionality from protecting areas unsuitable to forestry is low (Independent consultant, personal communication, October 4, 2022).

These areas would not be used for production forests in any case because the cost-benefit ratio is too high. Still, such areas can offer a good starting point on which to expand.

Economic diversity
Economic diversity can be further divided in input and output factors. Finding different resources and making more efficient and flexible use of them should lead to a reduced need for inputs, thereby reducing their chance of depletion. A greater variety of resources allows for flexibility by having the option to shift to alternatives. Increased efficiency requires a lower quantity of that resource being needed for the same level of outputs. A diversity of outputs like different products and ways to add value or new functions to products can reduce dependency on a single output/product. Increasing the economic value of a forest is regarded as beneficial because it creates an incentive for people to protect and maintain the forest (Treevive, personal communication, October 13, 2022; Independent consultant,). Overall, nurturing diversity of all sorts is regarded as beneficial to the resilience of a system by maintaining potential new opportunities (Berkes, 2007).

Managing for diversity
During the interviews, many experts described ways in which a forest manager could promote diversity. This connects to the impact investing philosophy of creating positive impact, rather than only avoiding negative impact i.e. managing to increase diversity, not only to reduce harm. If managers are really serious about contributing to conservation, it would be helpful to show this intention by setting a biodiversity objective and plan to work towards achievement of it. That way, investors will be able to see that managers are serious about making a positive impact. Similarly, adherence to certification standards is incredibly important to show intentionality and maintain credibility as discussed in sub-section 4.1.1.

In addition to habitat mapping, the quality of habitats for biodiversity should be evaluated and monitored as well. One interviewee mentioned complexity as a proxy for biodiversity (SLM partners, personal communication, October 7, 2022). The idea is that more complexity in a given habitat should contain higher levels of biodiversity (Augustynczik et al., 2019; Gustafsson et al., 2020; Oettel & Lapin, 2021). Complexity can also be captured in a single index value that allows for comparison between areas and monitoring over time (Ehbrecht et al., 2017; McElhinny et al., 2005).

4.2.2 Manage connectivity
Four themes were identified that related to managing connectivity. These are social connectivity, institutional connectivity, infrastructural connectivity and ecological connectivity. The first three were derived from the operationalisations in the literature and the fourth emerged from the interviews.

Social connectivity
Social connectivity refers to the relationships between individual people. Strong social networks with high levels of trust can foster resilience. People have others that they can receive support from. Overall, for institutional and social connectivity, it is important to not simply ‘link’ actors. The real benefit occurs when differences such as variations in terminologies are bridged. This is especially important when organisations and people operate in different fields. Actors should not only *talk*, but really *speak* to each other.

Institutional connectivity
Managing institutional connectivity means finding links with government or scientific institutes to strengthen the network. This implies a stakeholder mapping exercise to identify relevant organisations (Aligica, 2006). Governments may be able to offer subsidies or link projects to other development plans (Panpakdee & Palinthorn, 2021). An important consideration here is cross-scale linkages (Panpakdee et al., 2021). For example, project goals may be linked to global frameworks such as the sustainable development goals (SDGs). At the local or regional scale, connections may be established with scientific organisations or NGOs that are active in the area. Through these connections, options to combine

efforts or offer support and knowledge may arise. In addition to cross-scale linkages, also cross-sectoral collaboration is important to strengthen sustainable business models and enhance social-ecological resilience (Dentoni et al., 2021).

Infrastructural connectivity

Infrastructural connectivity revolves around access. This could be access to cities and markets to be able to buy resources and sell products. It can also be cognitive access in the sense that markets are known to people and they are able to learn about any developments. On the other hand, unwanted access to resources should be limited. Even though access to a forest can provide a new income opportunity to people, it also facilitates forest degradation. Road networks often enable illegal logging and poaching in places that were previously inaccessible (Laurance et al., 2015). So it is key to consider who benefits from connectivity and who loses here.

To meet this criterium, forest managers should show how desired infrastructure for surveillance or other activities like ecotourism is improved. In contrast, undesired movements in the landscape (e.g. poachers, pests, invasive species) should be restricted. For example, the establishment of buffer zones could help reduce external effects while simultaneously increasing ecological connectivity (Generation Forest Invest, Personal communication, October 27, 2022).

Ecological connectivity

Managing ecological connectivity means, in practice, connecting habitats and allowing ecological processes and migration of species to occur (Ashrafzadeh et al., 2020). The management plan should show a consideration of different habitat types as well as structural and functional connectivity for species, not merely protecting some isolated 'islands' of forest (Individual consultant, personal communication, October 4, 2022). Structural connectivity refers to the arrangement of elements in the landscape. Functional connectivity however, is the extent to which movement is possible or restricted. As functional connectivity is less static it may require monitoring to see which species and how many individuals *actually* move (Keeley et al., 2021).

Besides connectivity within the area under management, also position within the landscape and connection to external elements should be considered. One interviewee commented about the lack of attention to the surrounding landscape in certification standards (Independent consultant, personal communication, October 10, 2022). Another interviewee mentioned the use of proximity to protected areas or standing forest in the surrounding landscape to evaluate potential biodiversity impact (Generation Forest Invest, personal communication, October 27, 2022). This idea is reflected in the IRIS+ metrics as 'Area of adjacent protected land' (GIIN, n.d.). Other tools have been developed to check the location of key biodiversity areas (KBAs) or protected areas such as the Integrated Biodiversity Assessment Tool (IBAT).

4.2.3 Manage slow variables and feedbacks

Understanding the underlying drivers of change and historical patterns was an important theme in the literature. Among these, climate change was regarded as the most important driver of change. From the interviews, it became apparent that risk management is one of the cornerstones of investing that linked to this principle.

Understanding the underlying drivers of change and historical patterns

The general theme in the literature regarding slow variables and feedbacks is to focus on the underlying drivers of change, not merely their manifestations (Burgess & Beruvides, 2020). For example rather than only trying to combat forest fire, one should also aim to tackle the dry conditions and careless tossing of cigarettes that could be underlying drivers. A distinction is made between shocks and stressors, and biophysical and socio-economic disturbances. Shocks refer to relatively short-term, single issue disturbances (González-Quintero & Avila-Foucat, 2019; Turner II et al., 2003). Stressors, on the other hand, can be seen as slowly changing processes over a prolonged period (González-Quintero & Avila-Foucat, 2019; Turner II et al., 2003). The second distinction differentiates

between disturbances that can be viewed as predominantly causing changes to the biophysical or socio-economic subsystems.

In the publications from the literature survey, stressors occurred more than shocks, and biophysical more than socio-economic disturbances. Among these, climate change is the most dominant disturbance and is covered by 15 papers while other biophysical stressors (Table 2) arose only in one or two papers each.

Table 2: Table showing the occurrence (% of publication) of disturbances per category, with some examples of disturbances. A full list of disturbances identified in the literature is included in appendix F.

	Stressors	**Shocks**
Biophysical	climate change, changed precipitation patterns, changed wind conditions, eutrophication, overexploitation, mining, biodiversity loss, habitat loss, habitat fragmentation	earthquake, tsunami, hurricane, drought, bark beetle outbreak pest outbreak, late frost, predation, flooding, storms, El Niño, fire, landslides, diseases, pest outbreaks
	72%	34%
Socio-economic	population growth, economic development, urbanization, rising operational costs, growing competition, evolving regulatory frameworks, changing consumption patterns, mass tourism	market instability, price volatility, pandemic, new regulations, financial crisis, delay in payments, policy change, sabotage, loss of iconic species, temporal overtourism, boycott
	41%	34%

The aim of understanding the underlying drivers of change and historical patterns is to identify underlying deficiencies in the system that make it susceptible to disturbance (Cheer et al., 2019). Looking into historical patterns can also help to understand the current situation and dynamics (Cosens & Fremier, 2018). Interviewees also mentioned that historical analysis is necessary to make sure no deforestation has taken place just to allow establishment of a forest plantation for example (ASN Bank, personal communication, September 21, 2022). Understanding historical and current patterns also helps making projections for future scenario's (Face the Future, personal communication, October 25, 2022). Based on these scenario's, the forest company could identify priorities for management.

Climate change mitigation

As discussed above, climate change is the most commonly discussed disturbance in the literature. However, in the interviews climate change was considered not as the most important threat to forests but more as exacerbation of other disturbances. One interviewee mentioned that climate change is a contributing factor to other disturbances but that human activities are the main drivers of deforestation (Face the Future, personal communication, October 25, 2022). From this point of view, climate change does not directly lead to deforestation but is a slow variable acting in the background. In the literature, climate change was considered a risk while in the interviews it was mostly an opportunity. Specifically and opportunity to develop a business case through the sales of carbon credits.

Often sustainability is equated to climate. When talking about sustainability, investors talk about climate (Independent consultant, personal communication, October 4, 2022). A lot of investment funds and investors in those funds are motivated by their climate agenda (Form International, personal communication, October 12, 2022). Businesses are keen to buy carbon credits to offset their emissions. However, investing in forests for carbon sequestration is not necessarily an impact investment. A forest company that is not considered an impact investment still stores carbon. So to achieve additionality, an impact investor or company would have to do more than that. An example could be to employ 'engagement'. This means engaging in discussion with a carbon credit

buying organisation and providing recommendations on changes to their policy (ASN Impact Investors, personal communication, September 21, 2022). This would mean that a forest company not only sells carbon credits, but also sets requirements for the buyers to go beyond that. So not only offsetting emissions but also reducing emissions or making other environmental and/or social changes. Through such requirements the seller of carbon credits could make more impact than through sales of those credits alone could be achieved. This also provides an opportunity to discuss biodiversity and further increase the growing awareness of biodiversity impacts (FMO, personal communication, October 21, 2022).

Risk management

Risk management is a key aspect of investing (see section 4.1.2) that also occurred as a resilience strategy in the literature (e.g. Panpakdee et al., 2021). After identifying system components and their feedbacks, it is important to define thresholds and put monitoring and action plans in place (Burgess & Beruvides, 2020; Sellberg et al., 2021). Monitoring activities should notify managers in case a threshold is exceeded. An action plan outlines the necessary action to be taken in such instance. The aim is to manage a risk when it is still manageable and has not caused any irreversible changes (Allen et al., 2018). The planetary boundaries (Steffen et al., 2015) were mentioned as important global framework of slow variables that we should remain within (Wieland & Durach, 2021). This may help identify system variables but deciding on which variables are measured ultimately depends on an understanding of the system (Beauchamp et al., 2020).

4.2.4 Foster CAS-thinking

Complex adaptive systems thinking is mainly operationalised in the literature through adaptivity and acknowledgment of change and uncertainty. Even though they are presented as different themes here, they are closely linked.

Acknowledging change and uncertainty

Due to uncertainty, it is impossible to prepare for everything in detail. So the key is to be able to adapt to changing circumstances. Sellberg et al. (2021) discuss the development of alternative future scenarios or pathways as a way to explore levels of uncertainty. Forest managers should adopt this approach by building a range of uncertainty in their models. Expectations and assumptions in models (tree growth, carbon sequestration, weather patterns etc.) should show the existing uncertainty.

Adaptivity

Adaptivity builds upon the acknowledgement of uncertain future conditions and living with an element of change and uncertainty (McCarthy, 2014; Rölfer et al., 2022). Bohensky et al. (2015) have provided similar ways to foster CAS thinking in management such as incorporating systems thinking and embracing uncertainty (Knight et al., 2019; Rounsevell et al., 2021). Alternative pathway planning and creating different scenarios allows for flexibility in management. It is up to the manager to constantly adapt and revise management systems based on new insights.

4.2.5 Encourage learning and experimentation

Establishing a learning culture or environment is regarded as an important step towards resilience (Sellberg et al., 2021). Active learning with sufficient capacity and time available can give rise to new ideas and knowledge (Panpakdee et al., 2021; Panpakdee & Palinthorn, 2021). This is operationalised through three themes: knowledge coproduction/integration, monitoring and experimentation/ innovation.

Knowledge coproduction/integration

One of the main themes in the literature that links to the principle of learning and experimentation is knowledge coproduction or integration. Interdisciplinary research (Beauchamp et al., 2020; Trell et al., 2017), expert and public learning (Arnold et al., 2018) and the inclusion of local traditional knowledge

in management and monitoring practices greatly contribute to the production and integration of different types of knowledge (Cao et al., 2018; Salomon et al., 2019). Several authors highlight the opportunity to combine learning with participation through for example participatory monitoring (Caillon et al., 2017; Cundill et al., 2015; Ungar et al., 2020). Interviewees mentioned that they work together with research institutes or universities, for example in conducting inventories (Form International, personal communication, October 12, 2022). These combined efforts help to integrate and benefit from different types of knowledge.

Monitoring

Even though many authors in the literature discussed monitoring (e.g. Sellberg et al., 2021; Ungar et al., 2020), it was found hard to implement by the interviewees. One interviewee mentioned there is always more you would like to measure but you cannot measure everything (SLM Partners, personal communication, October 7, 2022). Especially since biodiversity is such a broad concept and there are many species, managers often opt for monitoring surrogate species (Form International, personal communication, October 12, 2022). These surrogates are a subset of species that have been taken as a proxy for all the species in the ecosystem (Treevive, personal communication, October 13, 2022). Monitoring a smaller selection of species requires less effort, while still providing useful data. Additionally, cooperation with third parties and disclosure of results adds a layer of transparency and credibility (Treevive, personal communication, October 13, 2022).

Experimentation

Innovation is considered by many as an essential property of a resilient social-ecological system (Allen et al., 2018; Ashkenazy et al., 2018; Wieland & Durach, 2021). In the interviews, a distinctions was made between experimentation with forest management techniques and innovative monitoring methods. Interviewees were generally very interested in a move towards more mixed stands and the use of native species as opposed to exotic monoculture plantations. Mixed stands are likely to be more resilient and beneficial for biodiversity (Castaño-Villa et al., 2019; Huuskonen et al., 2021; Wang et al., 2019). However, there is still a lack of knowledge regarding such silvicultural systems and more research on this topic is needed (Huuskonen et al., 2021; Liu et al., 2018). As mentioned above, another subject requiring further innovation is monitoring techniques. Interviewees mentioned the use of bio-acoustics (Alcocer et al., 2022) and e-DNA (Pärli et al., 2021) as promising techniques. However, these are not commonly implemented yet and many still use more established methods such as camera trapping (Generation Forest Invest, personal communication, October 27, 2022).

4.2.6 Broaden participation

The first theme relating to the broaden participation principle is to adopt a range of participatory methods. The second theme regarding participation is to increase benefit sharing.

Participatory methods

The involvement of local stakeholders is regarded as an important factor contributing to resilience. Local stakeholders can be involved in different phases of project development and implementation, from establishing the problem definition to employment and long-term monitoring. Many authors (e.g. Sellberg et al., 2021; Ungar et al., 2020) stress the importance of acknowledging the different normative values that stakeholders may have. There could be multiple norms and values and different 'desirable states' (Ehrnström-Fuentes & Kröger, 2017; Hoang et al., 2019) while participatory methods help in dealing with (epistemological) complexity (Sellberg et al., 2021). As such, it is important to involve stakeholders in defining the problems and possible solutions (Ungar et al., 2020) rather than providing the stakeholders with a problem analysis and solutions developed by scientists or external experts (Face the Future, personal communication, October 25, 2022). This will likely lead to better outcomes in the long run (Sterling et al., 2017).

Special consideration should go to Indigenous communities. These are increasingly being recognised as having a key role in the protection of forests and have now been included in the post-

2020 GBF (e.g. Target 19f). At the same time, they are prone to violation of their basic rights (Garcia et al., 2021). Therefore, any intervention that may affect those communities should obtain their free, prior and informed consent (FPIC) (Treevive, personal communication, October 13, 2022).

Benefit sharing

Benefit sharing could be an opportunity to align with wider development goals (SDGs) and to foster local support. At the same time, sharing of benefits could have a larger impact outside the project level or area under management. For example, providing people with agroforestry training could cause positive spillovers, or boosting effects in neighbouring areas (Bastos Lima et al., 2019) by promoting sustainable land use on a larger scale. Commodity production and (shifting) cultivation are important drivers of deforestation in many places (Ford et al., 2020) and reducing those drivers can be a great way to achieve additionality. Other examples that were mentioned by interviewees include providing facilities such as a hospital (ASN Bank, personal communication, September 21, 2022). A nearby hospital, or first aid centre, is a benefit for local communities while it is also necessary for the forest company in case any accidents happen during forestry operations. Interviewees also mentioned that the collection of NTFPs and providing beehives could be ways to provide benefits to local communities (Treevive, personal communication, October 13, 2022; Face the Future, personal communication, October 25, 2022). One way that many forest companies/funds aim to create direct benefits is through the creation of jobs just like the Arbaro Funds aims to do (Arbaro Fund, 2019). Besides measuring the number of jobs, job satisfaction interviews or questionnaires could provide insights into how people perceive those jobs (Unique forest investment, personal communication, December 12, 2022). This would be a welcome addition and explore the quality of those jobs.

4.2.7 Promote polycentric governance systems

The themes relating to the polycentric governance principle are all about scale. This includes temporal scale, spatial scale and balancing between those different scales.

Spatio-temporal scales

Defining the temporal and spatial scale of the focal system was often mentioned in the literature as an essential step in building resilience (Rölfer et al., 2022; Sellberg et al., 2021). Knowing *what* your system is, and what it is not, is necessary for defining the governance system. Once it is defined *what* is being governed, one can start looking at *who* will govern it. When decisions or changes are being made, decision makers should also consider the temporal scale and long-term changes they are adapting to. A focus on short-term gains may actually compromise long-term resilience of the system (Rölfer et al., 2022). Robards et al. (2011) provide the example that maximising timber production in the short-term may decrease regulatory ecosystem services (like soil retention) that are needed for long-term resilience. Managers should therefore ask themselves if their activities are short-term solution or also contributing to resilience in the long run.

Multi-scalar governance

Depending on the system and nature of the disturbance(s), the management unit and stakeholders can be defined. Each disturbance and ecosystem process has its own spatio-temporal scale (Müller et al., 2016) that may require different approaches. Environmental management often requires larger management units while social conflicts could be managed on a smaller scale (Andreassen et al., 2018). Moreover, including local decision making processes and traditional knowledge in management can foster cooperation and mutual benefits on the community level (Becker & Ghimire, 2003; Ulicsni et al., 2019; Yuliani et al., 2018).

5 Impact framework

This chapter presents the findings as discussed in chapter 4 in an actual impact framework. This framework outlines how impact investments in the forest sector can foster social-ecological resilience for biodiversity. Section 5.1 elaborates on the context of the framework and is followed by the framework itself (5.2, Table 3).

5.1 Setting the scene

Before diving deeper into the framework itself, it is important to clarify the context in which the framework can be applied. As discussed in chapter 2, building resilience is a normative exercise that involves answering the questions, resilience of what, against what, how, for whom and at which cost? These questions will be discussed below.

Resilience of what?

The answer to the first question (of what?) describes the focal system. In this case, the focal systems can generally be regarded as forests managed by a forest company. This includes all animals, plants and people living in it, as well as abiotic entities such as the soil or a river that flows through the area. In the end, the particular system variables or aspects will depend on the context of where that forest is located.

Against what?

The system is supposed to be resilient against a diversity of disturbances. Often, a distinction is made between general and specified resilience. Specified refers to the resilience of a system to a specific disturbance while general resilience is resilience towards different (combined or independent) disturbances (Folke et al., 2010). The framework is designed to be used with a focus on general resilience as disturbances to forests come in different forms, with different intensities and frequencies. Many examples of disturbances have been included in the results chapter (p.26).

How?

For answers to the question 'how?', the reader is referred to the impact framework. The criteria and indicators are essentially the answers to how social-ecological resilience is to be achieved. Forest companies could regard the framework as their guide in building (more) social-ecological resilience.

For whom?

The impact framework is specifically aimed at biodiversity. As discussed in section 2.1, this refers to the diversity in ecosystems, species and their genetic material. This does not mean that the company or local communities do not benefit from this framework. Some indicators exclusively refer to social aspects like social capital, employment and participation. In the end, these are expected to boost overall resilience, thereby benefitting biodiversity as well. Offering alternative income opportunities reduces dependency on the forest resources and the need to resort to logging, hunting or agriculture (Zenteno et al., 2013).

At the same time, a financially resilient forest company benefits biodiversity too. In many cases, the company engages in restoration/reforestation activities or protection that would not happen without the company or would require alternative sources of funding. In a sense, protection of these restored habitats is then dependent on the company and investors (Sullivan, 2018). Because the forest provides an economic benefit to its managers/investors, there is a strong incentive for them to protect it.

At which cost?

Applying the framework below and building SER should come at a cost to those who are focussed on maximising short-term gains. Implementation of the framework should contribute to maintaining forests and the biodiversity they contain in the long run. Maximising short term exploitation may

increase financial resilience of the company since profits are high. However, this can cause undesired consequences like overexploitation and soil depletion. At the same time, it offers no additional social and environmental benefits. Alternatively, the framework promotes a sustainable and steady supply of products (and profits), social benefits like jobs and the conservation of biodiversity in the long run.

5.2 The impact framework

The impact framework is presented in the table covering the next several pages.

Table 3: Impact Framework based on the social-ecological resilience principles with criteria and indicators.

Social-Ecological Systems Resilience Principles	**Criteria**	**Indicators**	**Comment/explanation**
Maintain diversity and redundancy	Maintain biological diversity	1. Habitat type inventory and mapping 1.1. Assessment of High Conservation Value (HCV) areas or critical/natural habitat and remaining natural forest 1.2. Plan to protect, restore and expand existing HCV areas, critical/natural habitat or natural forest to at least 30% of project area 1.3. A map of the identified habitats is provided	HCV approach and IFC-PS 6 are two methodologies that can guide identification of significant areas for conservation and restoration. The 30 x 30 initiative aims to protect 30% of the planet by 2030 (Zeng et al., 2022). Including private lands is necessary to achieve this (Saunders et al., 2023), highlighting the role that forestry companies can play. Active restoration (Cerullo & Edwards, 2019) and including different habitats that could be linked to the principle of managing connectivity (Fischer et al., 2006; Pomoim et al., 2022). For example, along streams (Kuglerová et al., 2014) as these areas are also the most difficult/unsuitable areas for forestry. Restoration activities can be guided by the International Principles & Standards for the Practice of Ecological Restoration (Gann et al., 2019).
		2. Baseline inventory of flora and fauna on newly acquired land 2.1. Fauna inventory, in cooperation with third parties 2.2. Flora inventory, in cooperation with third parties 2.3. Disclosure of inventory results, based on (IUCN) conservation status, national conservation status lists and CITES	Contribute to the measurability and transparency of impacts. A baseline study should be conducted on newly acquired land. Irrespective of newly established projects (greenfield) or existing companies/projects (brownfield) the situation at the start of the investment should be known. This provides necessary information for the monitoring plan (indicator 21). IUCN Red List and CITES are well-known, globally applicable, and generally accepted (ASN Impact Investors, personal communication, September 21, 2022).
	Maintain market diversity	3. Produce a diversity of products or services 3.1. Number of income streams (e.g. timber sales, carbon credits, lease of land, ecotourism)	Strengthen economic value and resilience of the forest. Payment for Ecosystem Services (PES) could play a role

		3.2. Number of marketable timber species/NTFPs (if applicable)	(Matthies et al., 2015) i.e. carbon credits, or alternatives like easement sales and ecotourism. Reduce pressure on a single resource (e.g. foster the use of lesser-known timber species (LKTS)). FSC (2018) does use sustained yield but does not specify by species. Even selective harvesting may overexploit commercially valuable species and reduce their genetic diversity (Acosta-Hernández et al., 2022; Widiyatno et al., 2017).
		4. Support local entrepreneurial initiatives to add value to standing forests (e.g. sawmill, industry) 4.1. It is shown how different parts of the value chain or end product are supported locally	Strengthen local economy and economic value of the forest (Harrison et al., 2022). May also create more incentive for local people to support protection of the forest and contribute to it.
	Manage for diversity and redundancy	5. Disclose intention for biodiversity conservation and sustainable management 5.1. Set biodiversity objective, with plan to achieve it 5.2. Report according to IFC-PS 6	Intentionality: Disclose intentions for protection, conservation and sustainable use of biodiversity. A plan that outlines how this intention will be achieved greatly enhancing credibility and will make investors more confident.
		6. Sustainable management with certification or intention to achieve this: 6.1. In case of timber production: e.g. FSC, PEFC, SFI; Carbon credits: e.g. Verra VCS, Plan Vivo; Agri-commodity: e.g. Rainforest Alliance 6.2. Verra Climate, Community & Biodiversity (CCB) certified, or intention to achieve this	Shows intention and improves credibility (Paluš et al., 2021). Although it is still difficult to prove impact (Van der Ven & Cashore, 2018) certification is suggested to have added value for biodiversity (Lehtonen et al., 2021). CCB standard covers many of the indicators included in this framework so could be a way to cover these.
		7. Manage for complexity in forest stands 7.1. Periodic measure of Stand Structural Complexity (SSC) index	"The more complex that forest is, the more biodiversity it's gonna have." (SLM partners, personal communication, October 7, 2022). Complexity could be used as a proxy for biodiversity (Augustynczik et al., 2019; Gustafsson et al., 2020; Oettel & Lapin, 2021) as represented by an index value (Ehbrecht et al., 2017; McElhinny et al., 2005).
Manage connectivity	Social connectivity	8. Grievance policy 8.1. Report according to IFC-PS 1, with clear procedure describing how complaints are dealt with	Prevents action without consent and fosters local support and trust. A protocol to follow-up on receiving grievances is necessary (Pasaribu et al., 2020).

		9. Increase social capital 9.1. Periodic social capital assessments	Higher social capital is associated with more positive attitudes and cooperation (Qiu et al., 2021; Ros-Tonen & Derkyi, 2018). Social capital boosts resilience (Aldrich & Meyer, 2015; Kizos et al., 2014) by providing access to various resources (financial, aid, information, emotional and psychological support).
	Institutional connectivity	10. Assessment of relevant institutions at the local, regional, national and international scale 10.1. Conduct at least a basic institutional stakeholder mapping exercise, highlighting role and potential benefits of each organisation and institutional frameworks	Understand (potential) relationships between institutions and show possibility to combine efforts, or at least not be counterproductive, and receive grants (Aligica, 2006).
		11. Connect with network organisations or sector initiatives 11.1. Fund manager or partners are member of network organisations (e.g. GIIN, PBAF, Finance for Biodiversity Pledge) or associations	Foster learning and up-to-date knowledge on developments. Collaboration is important in sustainable business models and supporting SER (Dentoni et al., 2021).
	Infrastructure connectivity	12. Manage physical access to conservation areas (like HCV areas) 12.1. Unwanted influence/access is reduced 12.2. Infrastructure for management/surveillance/ ecotourism is improved	Establishment of buffer zones could help reduce external effects and increase ecological connectivity (indicator 16). (Generation Forest Invest, Personal communication, October 27, 2022).
	Ecological connectivity	13. Manage ecological connectivity in the landscape 13.1. Credible narrative of how (restoration) activities improve functional connectivity in the landscape, including a map 13.2. Include connectivity metrics in monitoring plan	Habitat connectivity is important (Ashrafzadeh et al., 2020). Narrative should show a consideration of different habitat types as well as structural and functional connectivity for species. Structural connectivity is more static and could be indicated on a map. Functional connectivity however, may require monitoring (Keeley et al., 2021). As such, this effort can be combined with indicator 21 (monitoring) with motivated selection of surrogate species (Meurant et al., 2018).
		14. Assessment of protected areas in the landscape 14.1. Any Key Biodiversity Areas (KBA) or Protected Areas[1] inside and up to 1 km around the project area are identified 14.2. Report on 'area of adjacent protected land'	The Integrated Biodiversity Assessment Tool (IBAT) could be of use for this. Area of adjacent protected land is part of the IRIS+ metrics (GIIN, n.d.). Connection with other areas improves connectivity while restoration forests/plantations

			can act as a buffer (Brockerhoff et al., 2008; Denyer et al., 2006).
Manage slow variables and feedback	Underlying drivers/historical patterns	15. Historical patterns 15.1. Historical analysis of the landscape, at least before time of deforestation/forests degradation and show projections for the future (baseline scenario)	Identifying historical patterns or drivers of deforestation/degradation fosters understanding of the current situation. It also helps to show the additionality of the project by showing what is likely to happen in the area in absence of the project. Developing a baseline scenario is already a requirement for many carbon schemes.
		16. Identify main drivers of change (risks) and solutions to address them 16.1. Report on Taskforce on Nature-related Financial Disclosures (TNFD) framework	The TNFD framework provides an international standardised approach. The new version of TNFD should include ownership rights. If not, special attention should go to this. Many conflicts have to do with access, land use and ownership (Hoang et al., 2019) (link to indicator 26, participatory problem definition).
	Risk management	17. Manage risks 17.1. Monitoring programme with thresholds and action plan 17.2. Plan to avoid or mitigate the manifestations and spreading of invasive species, pests, fire or other risks	A monitoring programme increases understanding of the system while a combination of relevant indicators with thresholds can notify about any undesired changes. (Carpenter et al., 2001). Indicator 17.2 could be covered by FSC certification and IFC Performance Standards.
	Climate change mitigation	18. Contribute to climate change mitigation 18.1. Company/fund stimulates their buyers of carbon credits (if applicable) to reduce emissions as part of a wider strategy in climate change mitigation	Carbon sequestration by forests can play a role in mitigation but is not the only solution to climate change so wider emission reductions are needed, not only offsets. Encourage companies to align with Science Based Targets initiative (SBTi) and Paris Agreement.
Foster complex adaptive systems (CAS) thinking	Acknowledge change and uncertainty	19. Consider alternative pathways 19.1. Models show uncertainty and consider alternative pathways	Uncertainty is an inherent aspect of (conservation) management decision making (McCarthy, 2014). Bohensky et al. (2015) have already provided ways to foster CAS thinking in management such as incorporating systems thinking and embracing uncertainty (Knight et al., 2019; Rounsevell et al., 2021).
	Adaptivity	20. Adaptive management plan 20.1. Regularly adapt management plan according to monitoring results or other acquired knowledge	It is impossible to prepare for everything in detail. So the key is to be able to adapt to any changing circumstances.

Encourage learning and experimentation	Monitoring	21. Periodic monitoring of flora and fauna 21.1. Periodic fauna inventory with motivated selection of surrogate species, in cooperation with third parties 21.2. Periodic flora inventory, in cooperation with third parties 21.3. Disclosure of inventory results	Monitoring is an essential part of the learning process. Monitoring activities, can notify about any changes in species composition and abundance. At the same time, it can increase understanding of the system. Periodic repeat will show trends and help to show the actual impact that the project has made.
	Knowledge coproduction/ integration	22. Institutions involved in research 22.1. Show which organisations (institutions) are involved in research and describe what their role is	For example, research institutes/universities, NGOs, nurseries.
		23. Different actors are involved in learning activities 23.1. The number of (local) participants in learning activities like workshops and monitoring	Interdisciplinary research can enhance understanding among participants through for example participatory monitoring (Cundill et al., 2015).
	Experimentation	24. Trials with reforestation/silvicultural techniques: 24.1. Establishing mixed species stands, and/or; 24.2. Using native species, and; 24.3. Disclosure of trial results	To contribute to the ongoing research on mixed-species plantations (Liu et al., 2018) as mixed stands are likely to be more resilient and beneficial for biodiversity (Castaño-Villa et al., 2019; Huuskonen et al., 2021; Wang et al., 2019). Mixed stands also contribute to market diversification. However, more research on suitable sylvicultural regimes is needed (Huuskonen et al., 2021).
		25. Trials with monitoring methods 25.1. Innovative monitoring methods are being used and; 25.2. Disclosure of trial results/findings	For example, try the use of bio-acoustics (Alcocer et al., 2022), (e-)DNA (Pärli et al., 2021) or explore other options.
Broaden participation	Participatory methods	26. Participatory problem definition and proposed solutions 26.1. A participatory process takes place before start of a project that results in a common definition of the desirable state	There could be multiple norms and values and different 'desirable states' (Ehrnström-Fuentes & Kröger, 2017; Hoang et al., 2019). Participatory methods help in dealing with (epistemological) complexity (Sellberg et al., 2021) and could lead to better outcomes (Sterling et al., 2017).
		27. Clear policy on the relationship with indigenous peoples 27.1. Report according to IFC-PS 7, especially the process of obtaining Free, Prior and Informed Consent (FPIC)	Indigenous peoples play a pivotal role in managing and conserving the world's forests, as is now also recognised by the Convention on Biological Diversity (CBD) in the post-2020 Global Biodiversity Framework (GBF).

	Benefit sharing	28. Sharing of benefits from the project/company 28.1. Number of local people formally employed and job satisfaction score 28.2. Number of people provided with training (e.g. agroforestry practices/monitoring) and satisfaction score, and/or; 28.3. Other (public) benefits provided (e.g. improved roads, beehives, NTFPs)	A job satisfaction score gives a qualitative results that provides more insight into the effects and perceived benefits. Training could cause positive spillovers, or boosting effects (Bastos Lima et al., 2019), by promoting sustainable land use outside the project area. Commodity production and (shifting) cultivation are important drivers of deforestation in many places (Ford et al., 2020). Engaging people in monitoring is an excellent way to combine learning and participation and increase involvement of local people. This could also be an opportunity to align with wider development goals (SDGs).
Promote polycentric governance systems	Spatial scale	29. Clearly define system boundaries 29.1. Management plan includes the area of at least 1 km surrounding the area under management	Encourage a focus on the landscape level rather than project area (area under management) only (Rölfer et al., 2022). Ecosystem services and biodiversity do not stop at project borders. As such, significant ecosystems and communities are identified and considering in the management plan.
	Temporal scale	30. Focus on long-term resilience of the system 30.1. Set long-term goals (10-100 years) and show how short-term action will lead to achieving those goals	A focus on short-term gains may actually compromise long-term resilience of the system (Robards et al., 2011).
	Multi-scalar governance	31. Adjust decision making levels to scale 31.1. Define scale of the problem to be dealt with 31.2. Consider local traditional authority	Disturbances and ecosystem processes have different spatio-temporal scales (Müller et al., 2016). Environmental management may require larger management units while social conflicts could be managed on a smaller scale (Andreassen et al., 2018). Including local decision making processes and traditional knowledge in management can foster cooperation and mutual benefits (Becker & Ghimire, 2003; Ulicsni et al., 2019; Yuliani et al., 2018).

1 Key Biodiversity Areas (BKAs)/UNESCO biosphere reserve/RAMSAR site/Natura 2000/National Protected Areas or other.

6 Testing the framework

In this chapter the framework is tested on two cases of impact investments (forestry companies). The table on the following pages (Table 4) shows the indicators from the impact framework (chapter 5) with a small description of how the companies relate to it. This shows to what extent these cases of impact investments in the forest sector meet the requirements set by the framework or where current shortcomings are. The goal of this assessment is not to provide investment advice but to compare how information on the cases relates to the impact framework. Section 6.1 discusses some of the main findings from the assessment and highlights where differences between the impact framework and the cases are.

6.1 Findings

In general, the Arbaro Fund and portfolio companies (Forestal San Pedro and Forestal Apepú) show thorough analysis of the landscape and awareness of possible adverse impacts. However, specifically regarding biodiversity impact there is room for improvement in terms of intentionality, additionality and measurability. For example, the fund has no explicit biodiversity objective (indicator 5, Table 4). Apepú does have the objective to "protect natural forests and other sensitive areas within the project area" (Arbaro Advisors, 2021, p.10). However, to a large extent this is already a requirement by Paraguayan law, questioning the additionality of such objective. As indicated by the framework, ways to increase additionality could be focussing on quality of these forests and their connectivity or role in the landscape. Restoration activities, even within degraded patches of original natural forest can improve their quality and conservation value. Similarly, connection with the surrounding landscape and land uses may be strengthened. For example, Laino et al. (2022) discuss synergies between patches of forests and the surrounding savanna landscape in the Paraguayan Humid Chaco.

Another important finding is that it can be hard to retrieve or locate specific responses to the indicators. This is not surprising given that the documents were not written with the impact framework in mind. Though, it shows that disclosure of information may not facilitate assessment by an investor who is evaluating potential biodiversity impact of any investment. For example, the Environmental and Social Impact Assessments (ESIAs) explore protected areas but they do not mention other type of areas that may be important like Key Biodiversity Areas (KBAs), RAMSAR sites and UNESCO biosphere reserves. This leaves up to question whether these have not been assessed, or have been assessed but not found in the area. Moreover, the public summaries of the management plans (UNIQUE, 2021, 2022) are in Spanish which does not facilitate use by non-Spanish speaking investors. Since these management plans contain much useful information including monitoring results, it would be highly valuable to provide these in English as well.

Overall, social-ecological resilience thinking is not easily identifiable in the cases. For example, there is a risk management plan in place with mitigation measures. But to what extent is there adaptive capacity in the companies/fund to deal with unexpected events or trajectories? It seems forest management is more an example of ecological resilience where the aim of the manager is to establish a certain 'state' and protect it from change. However, we may questions the long-term viability of this approach given that climatic and meteorological patterns and forest dynamics are altering drastically (IPCC, 2022; McDowell et al., 2020). Maybe forest management should be more anticipative on these changes and manage for social-ecological resilience (see Nikinmaa et al., 2023). Managers may think of an answer to the question: how will this investment lead to a resilient forest in about 50 years or so?

Table 4: Assessment of two plantation forestry companies in Paraguay. Table shows the indicators and descriptions of the relevant characteristics of each company.

Indicators	**Forestal San Pedro**	**Forestal Apepú**
1. Habitat type inventory and mapping 1.1. Assessment of High Conservation Value (HCV) areas or critical/natural habitat and remaining natural forest 1.2. Plan to protect, restore and expand existing HCV areas, critical/natural habitat or natural forest to at least 30% of project area 1.3. A map of the identified habitats is provided	• HCV areas have been identified. • According to Paraguayan law, the company should restore and conserve 25% of the forest area that was present in 1986 (Original Wooded Area) and protect buffer zones around springs and streams. No active restoration to 30% of project area is taking place. • Baseline land use or habitat types have been mapped. (GEOCONSULTORES, 2020).	• Assessment has been conducted and remnant patches of natural forest will be set aside for conservation. Survey of HCV areas has been conducted but none were identified. • According to Paraguayan law, the company should restore and conserve 25% of the forest area that was present in 1986 (Original Wooded Area) and protect buffer zones around springs and streams. No active restoration to 30% of project area is taking place. • Baseline land use or habitat types have been mapped. (Arbaro Advisors, 2021)
2. Baseline inventory of flora and fauna on newly acquired land 2.1. Fauna inventory, in cooperation with third parties 2.2. Flora inventory, in cooperation with third parties 2.3. Disclosure of inventory results, based on (IUCN) conservation status, national conservation status lists and CITES	Baseline inventories of flora and fauna have been conducted. Bird, mammal, amphibian and reptile species that were found are provided with their endemic and (inter)national conservation status. For flora, only the recorded species have been provided, without mention of their conservation status. (GEOCONSULTORES, 2020).	A team of biologists was hired to conduct a field study. Mammal, bird, reptile and tree species with endemic or conservation status from IUCN, national list of endangered species (MADES) and CITES appendix II are reported (Arbaro Advisors, 2021). Unclear whether for example, amphibians, insects or herbaceous plants were included in the study.
3. Produce a diversity of products or services 3.1. Number of income streams (e.g. timber sales, carbon credits, lease of land, ecotourism) 3.2. Number of marketable timber species/NTFPs (if applicable)	Company aims to produce/offer: 1. High-quality veneer and saw logs of eucalypt 2. Biomass as by-product 3. Carbon credits	Company aims to produce/offer: 1. High-quality veneer and saw logs of eucalypt 2. Biomass as by-product 3. Carbon credits

	(GEOCONSULTORES, 2020; Unique forest invest, personal communication, February 26, 2023).	4. Agriculture on land that has not been planted yet and cattle grazing in silvopastoral systems. (Arbaro Advisors, 2021).
4. Support local entrepreneurial initiatives to add value to standing forests (e.g. sawmill, industry) 4.1. It is shown how different parts of the value chain or end product are supported locally	The company foresees the instalment of a sawmill once stands have reached maturity (GEOCONSULTORES, 2020).	*Unspecified*
5. Disclose intention for biodiversity conservation and sustainable management 5.1. Set biodiversity objective, with plan to achieve it 5.2. Report according to IFC-PS 6	The Arbaro Fund requires companies to report according to the IFC Performance Standards (Arbaro Fund, 2022). However, no specific biodiversity objective has been set.	The Arbaro Fund requires companies to report according to the IFC Performance Standards (Arbaro Fund, 2022). However, no specific biodiversity objective has been set.
6. Sustainable management with certification or intention to achieve this: 6.1. In case of timber production: e.g. FSC, PEFC, SFI; Carbon credits: e.g. Verra VCS, Plan Vivo; Agri-commodity: e.g. Rainforest Alliance 6.2. Verra Climate, Community & Biodiversity (CCB) certified, or intention to achieve this	Forests have been FSC certified since 2014 (GEOCONSULTORES, 2020). The Arbaro Fund aims to generate carbon credits according to the Verra VCS standard. If it would be deemed to be of additional value to investors, Arbaro will consider Verra CCB certification (Arbaro Fund, 2022).	For each portfolio company, FSC certification will be achieved within three years after the investment and maintained thereafter (Arbaro Fund, 2022). The Arbaro aims to generate carbon credits according to the Verra VCS standard. If it would be deemed to be of additional value to investors, Arbaro will consider Verra CCB certification (Arbaro Fund, 2022).
7. Manage for complexity in forest stands 7.1. Periodic measure of Stand Structural Complexity (SSC) index	*Unspecified*	*Unspecified*
8. Grievance policy 8.1. Report according to IFC-PS 1, with clear procedure describing how complaints are dealt with	Company has a grievance mechanism in place and adopts the IFC Performance Standards. The Arbaro Fund also allows stakeholders to express their complaint to fund management directly, for which policy and procedures are described in detail.	Company has a grievance mechanism in place and adopts the IFC Performance Standards. The Arbaro Fund also allows stakeholders to express their complaint to fund management directly, for which policy and procedures are described in detail.
9. Increase social capital 9.1. Periodic social capital assessments	*Unspecified*	*Unspecified*

10. Assessment of relevant institutions at the local, regional, national and international scale 10.1. Conduct at least a basic institutional stakeholder mapping exercise, highlighting role and potential benefits of each organisation and institutional frameworks	*Unspecified*	Stakeholder organisations have been identified and their relevance has been described (UNIQUE, 2021).
11. Connect with network organisations or sector initiatives 11.1. Fund manager or partners are member of network organisations (e.g. GIIN, PBAF, Finance for Biodiversity Pledge) or associations	Fund manager (Finance in Motion) is a member of the GIIN Investors Council and PBAF.	Fund manager (Finance in Motion) is a member of the GIIN Investors Council and PBAF.
12. Manage physical access to conservation areas (like HCV areas) 12.1. Unwanted influence/access is reduced 12.2. Infrastructure for management/surveillance/ ecotourism is improved	Illegal activities (particularly hunting, fishing and the use of fire) are identified and controlled (GEOCONSULTORES, 2020; Unique forest invest, personal communication, February 26, 2023).	Illegal activities (particularly hunting, fishing and the use of fire) are identified and controlled (Arbaro Advisors, 2021; Unique forest invest, personal communication, February 26, 2023).
13. Manage ecological connectivity in the landscape 13.1. Credible narrative of how (restoration) activities improve functional connectivity in the landscape, including a map 13.2. Include connectivity metrics in monitoring plan	Plantation is expected to function as a wildlife corridor. Monitoring results will have to show what happens in practice (Unique land use, 2022).	Plantation is expected to function as a wildlife corridor. Monitoring results will have to show what happens in practice (Unique land use, 2022).
14. Assessment of protected areas in the landscape 14.1. Any Key Biodiversity Areas (KBA) or Protected Areas[1] inside and up to 1 km around the project area are identified 14.2. Report on 'area of adjacent protected land'	Assessment of all protected areas with IUCN or National System of Protected Areas of Paraguay (SINASIP) status in the relevant departments has been conducted (GEOCONSULTORES, 2020). Key Biodiversity Areas (KBA) are not mentioned in the Environmental and Social Impact Assessment (ESIA). No area of adjacent protected land specified.	Protected areas are included in the Environmental and Social Impact Assessment (ESIA). Apepú borders the Tapiracuai stream to the south, which is an IUCN category IV protected area (UNEP-WCMC, 2023). Key Biodiversity Areas (KBA) are not mentioned in ESIA. No area of adjacent protected land specified.
15. Historical patterns 15.1. Historical analysis of the landscape, at least before time of deforestation/forests degradation and show projections for the future (baseline scenario)	Historic situation is described. However, main drivers of deforestation/degradation in the project area are not clearly discussed in the documents.	Historic situation is described. Important drivers of deforestation and degradation included overexploitation and expansion of agricultural land for livestock.

	No future projections of the baseline scenario are given i.e. the counterfactual or business-as-usual (what would likely happen to the area in absence of the project).	No future projections of the baseline scenario are given i.e. the counterfactual or business-as-usual (what would likely happen to the area in absence of the project).
16. Identify main drivers of change (risks) and solutions to address them 16.1. Report on Taskforce on Nature-related Financial Disclosures (TNFD) framework	Identification of risks should be covered by IFC-PS 1. No use is made of the TNFD framework.	Identification of risks should be covered by IFC-PS 1. No use is made of the TNFD framework.
17. Manage risks 17.1. Monitoring programme with thresholds and action plan 17.2. Plan to avoid or mitigate the manifestations and spreading of invasive species, pests, fire or other risks	The main environmental and socio-economic risks have been identified (GEOCONSULTORES, 2020). For each of those risks a monitoring plan and mitigation measures are described.	Adverse social and environmental impacts (risks) have been identified and assessed on likelihood, severity, scale, duration, permanency and significance (Arbaro Advisors, 2021). Mitigation measures for each risk are provided.
18. Contribute to climate change mitigation 18.1. Company/fund stimulates their buyers of carbon credits (if applicable) to reduce emissions as part of a wider strategy in climate change mitigation	*Unspecified*	*Unspecified*
19. Consider alternative pathways 19.1. Models show uncertainty and consider alternative pathways	No description of changes in for example climate, precipitation patterns, demographic are given and how these may impact the project.	No description of changes in for example climate, precipitation patterns, demographic are given and how these may impact the project.
20. Adaptive management plan 20.1. Regularly adapt management plan according to monitoring results or other acquired knowledge	Forest Management Plan is updated on a regular basis based on monitoring results (Arbaro Fund, 2022).	Forest Management Plan is updated on a regular basis based on monitoring results (Arbaro Fund, 2022).
21. Periodic monitoring of flora and fauna 21.1. Periodic fauna inventory with motivated selection of surrogate species, in cooperation with third parties 21.2. Periodic flora inventory, in cooperation with third parties 21.3. Disclosure of inventory results	Biodiversity indicators such as species diversity and richness are included in a regular monitoring plan (Arbaro Fund, 2022). Companies are expected to report on “Listed species directly benefitting from protected habitat (#)” (Arbaro Fund, 2019, p.72). This refers to species with a conservation status according to the IUCN Red List, CITES	Biodiversity indicators such as species diversity and richness are included in a regular monitoring plan (Arbaro Fund, 2022). Companies are expected to report on “Listed species directly benefitting from protected habitat (#)” (Arbaro Fund, 2019, p.72). This refers to species with a conservation status according to the IUCN Red List, CITES

	Appendix II or national list of endangered species (MADES) that are protected in the project area. Results are shared in a public summary of the management plan (in Spanish) (UNIQUE, 2022).	Appendix II or national list of endangered species (MADES) that are protected in the project area. Results are shared in a public summary of the management plan (in Spanish) (UNIQUE, 2021).
22. Institutions involved in research 22.1. Show which organisations (institutions) are involved in research and describe what their role is	Collaboration with University of Asunción for research and development (Unique forest invest, personal communication, February 26, 2023).	Collaboration with University of Asunción for research and development (Unique forest invest, personal communication, February 26, 2023).
23. Different actors are involved in learning activities 23.1. The number of (local) participants in learning activities like workshops and monitoring	*Unspecified*	*Unspecified*
24. Trials with reforestation/silvicultural techniques: 24.1. Establishing mixed species stands, and/or; 24.2. Using native species, and; 24.3. Disclosure of trial results	*Unspecified*	Trials are being conducted with mixed stands including native species (FLILA, 2021). Some basic information on the silvicultural systems used in those trials is included in the management plan (UNIQUE, 2021). Trial sites are near remaining natural forest to gain potential benefits from connectivity. As of now, no disclosure of results or findings will take place other than through potential publications by researchers (Unique forest invest, personal communication, December 12, 2022).
25. Trials with monitoring methods 25.1. Innovative monitoring methods are being used and; 25.2. Disclosure of trial results/findings	*Unspecified*	Cooperation with the International Climate Initiative (IKI) funded by the German government on systematic monitoring (Unique land use, 2022). Research is ongoing so no results are available so far.
26. Participatory problem definition and proposed solutions	The company has a stakeholder participation process that allows participation from the	The company has conducted a Participatory Rural Appraisal to identify needs and wishes of local communities (Arbaro Advisors, 2021).

26.1. A participatory process takes place before start of a project that results in a common definition of the desirable state	project identification phase until the project ends (GEOCONSULTORES, 2020).	This led to the initiation of an agricultural project with those local communities.
27. Clear policy on the relationship with indigenous peoples 27.1. Report according to IFC-PS 7, especially the process of obtaining Free, Prior and Informed Consent (FPIC)	The Arbaro Fund (2022) requires all communities of indigenous peoples in the 'area of influence' to be identified. Companies will comply with IFC-PS 7 and ensure FPIC.	The Arbaro Fund (2022) requires all communities of indigenous peoples in the 'area of influence' to be identified. Companies will comply with IFC-PS 7 and ensure FPIC.
28. Sharing of benefits from the project/company 28.1. Number of local people formally employed and job satisfaction score 28.2. Number of people provided with training (e.g. agroforestry practices/monitoring) and satisfaction score, and/or; 28.3. Other (public) benefits provided (e.g. improved roads, beehives, NTFPs)	• About 108 local people were working directly for the plantations in 2022 (Unique forest invest, personal communication, February 26, 2023). Workers' satisfaction scores are included in the management plan (UNIQUE, 2022) • Employees are trained regularly on health and safety protocols (GEOCONSULTORES, 2020). Local service providers are encouraged to participate in trainings for professionalisation (Unique forest invest, personal communication, February 26, 2023). In addition, community campaigns are organised such as a fire prevention campaign in local schools (Unique forest invest, personal communication, February 26, 2023). • The project land is leased from farmers who use the silvopastoral plantations for cattle grazing (GEOCONSULTORES, 2020). In addition, outgrower schemes are used on a small scale (20 beneficiaries; Unique forest invest, personal communication, February 26, 2023). Trough an outgrower project, a local land owner can receive technical and material support as well as	• An estimated 225 Full Time Equivalents (FTE) of employment created directly and about 300 FTE indirectly (Arbaro Fund, 2021). This included about 120 local people working directly for the plantations in 2022 (Unique forest invest, personal communication, February 26, 2023). • Employees are trained regularly on health and safety protocols including firefighting (Arbaro Advisors, 2021). Local service providers are encouraged to participate in trainings for professionalisation (Unique forest invest, personal communication, February 26, 2023). In addition, community campaigns are organised such as a fire prevention campaign in local schools (Unique forest invest, personal communication, February 26, 2023). • Outgrower schemes are currently implemented with 5 beneficiaries on a total of 10 hectares (Arbaro Advisors, 2022). In addition, local communities (50 beneficiaries) are engaged in an agricultural project (vegetable garden) (Arbaro Advisors, 2022).

	50% of the profit from the sale of the wood (GEOCONSULTORES, 2020).	
29. Clearly define system boundaries 29.1. Management plan includes the area of at least 1 km surrounding the area under management	Unclear how the surrounding areas has an effect on, and is affected by, management of the project area.	The project area including surrounding area up to 1 km is considered as 'the area of influence.' Unclear how this is incorporated in the company's management decisions.
30. Focus on long-term resilience of the system 30.1. Set long-term goals (10-100 years) and show how short-term action will lead to achieving those goals	Goal is to create and maintain a permanent carbon stock and activities are tailored towards that.	Goal is to create and maintain a permanent carbon stock and activities are tailored towards that.
31. Adjust decision making levels to scale 31.1. Define scale of the problem to be dealt with 31.2. Consider local traditional authority	Scales of the problems/risks to be dealt with are not defined in the documents. Unclear how local traditional authority is considered.	Scales of the problems/risks to be dealt with are not defined in the documents. Unclear how local traditional authority is considered.

1 Others can include UNESCO biosphere reserve, RAMSAR site, Natura 2000, National Protected Area etc.

7 Discussion

This chapter first discusses the research and impact investing in the broader context (7.1). Section 7.2 contains some reflections on the research methods and obtained results.

7.1 Impact investing

Given the climate and biodiversity crises and high demand for wood products globally, solutions are urgently needed. Impact investments in forests could play an important role by addressing many challenges at the same time. The private forest sector can contribute to climate mitigation and the protection and restoration of natural forests while producing wood. The post-2020 Global Biodiversity Framework (GBF) has now explicitly recognised the private sector including impact funds as one of the key sources of funding for biodiversity conservation (CBD, 2022). The private sector contains vast amounts of money and investors are very interested in investing in the forest sector (FMO, personal communication, October 21, 2022). However, these investments are mostly confined to developed and safe countries with established forest industries like the US (Bass et al., 2019). Through the interviews, it became clear that institutional investors are reluctant to invest in developing countries due to the high risks associated with them (e.g. unclear land ownership and tenure rights) and the consequential reputational risks. One of the interviewed experts explicitly stated that 'risk is everything' (Independent consultant, personal communication, October 4, 2022). This focus on risk is reflected by the financial sector in the Netherlands (The Sustainable Finance Platform, 2020; Van Toor et al., 2020) but also on global platforms such as the World Economic Forum (WEF, 2020). Many publications from financial institutions discuss the dependency of the financial sector and global GDP on biodiversity. The general perception is that biodiversity loss is a risk to the financial sector or businesses and the reason we should invest in biodiversity conservation.

While acknowledging the risks of biodiversity loss and understanding the financial sector's contribution to it is an essential step, there is a need to move beyond that. This requires investors to shift from a risk-oriented to more opportunity-oriented approach (Treevive, personal communication, October 13, 2022). Such shift in mindset would guide financial institutions from protecting biodiversity to save businesses, to investing in businesses that save biodiversity. Through the latter approach, financial institutions could become part of the solution rather than trying to reduce their negative impact (Van Tilburg et al., 2022).

To maximise positive impact, investors may look for certain risks as these also come with opportunities, both financially and for biodiversity. Currently, investors may avoid investing in developing countries as forests are perceived as a complicated asset class with high reputation risks in those countries (Binkley et al., 2020). However, these areas offer tremendous opportunities for conservation and investments. These are the areas where a lot of impact could be made in terms of biodiversity protection, reforestation and sustainable production. Tropical regions contain most the world's forests but also the countries with the highest deforestation rates (FAO, 2020). This suggest that halting deforestation in these areas or working on restoration can have significant impacts on biodiversity. At the same time, these regions could be attractive to investors by offering higher returns due to lower costs of land, higher biological growth rates with shorter rotation periods while offering additional diversification benefits (Binkley et al., 2020).

Private investments, however, do not have to replace public funding. Public and private funding can exist simultaneously, either in different places or combined. Publicly funded protected areas could exist alongside privately funded production forests. They can also be combined through blended finance where public funding is used to attract more private investments (Bass et al., 2019). For example in places that are deemed too high risk for private investors, public money can be used to cover some of that risk. In case any loss would occur, this is subtracted from the public money first ('first loss') (Hervé-Mignucci et al., 2013). This could make private investors more confident.

Despite an explicit attention to creating positive impacts, financial returns remain paramount. As such, economic activities that allow a positive cash flow remain necessary. Examples of such

activities are production of timber or agricultural commodities, possibly supplemented by payments for ecosystem services (e.g. carbon credits). This productive side forces us to consider if investments follow a *land sharing* or *land sparing* approach (Green et al., 2005). Land sparing involves a clear distinction between conservation and production landscapes (Fischer et al., 2014). A combination of public funding for conservation with private investments in productive land uses follows the land sparing approach. In practice, this could mean that a large portion of forests (in the world or a given country) are protected through a network of protected areas in which no logging takes place, funded by public money and philanthropic donations. Outside these protected areas, there would be high intensive production forests that have as primary goal to meet the demand for wood products. These production forests could be funded by private sector investors. The land sharing approach, on the other hand, aims to maintain biodiversity within production landscapes (Fischer et al., 2014). This would mean more close-to-nature forestry systems with lower harvest rates that serve as habitat for biodiversity while providing wood products (Edwards et al., 2014; Gustafsson et al., 2020). Such approach would allow for less or smaller protected areas, if the same quantities of wood products are to be produced as in the land sparing approach. Consequently, more land would be available to private sector investments. In the end, a final decision on either approaches may not be reached or even necessary (Fischer et al., 2008; Phalan, 2018). The impact framework in this report can help improve the quality of tree plantations and natural (non-plantation) forests so that they may both contribute to biodiversity conservation. A combination of sustainably well-managed plantations alongside mixed, continuous cover forest systems and protected areas may offer us the best of both worlds (Paul & Knoke, 2015), and impact investments could help us get there.

In the end, impact investing could be a way to transform production forests and mobilise finance for conservation or restoration activities. Impact investing may be less suitable for funding pure conservation as investing requires a financial return and thus needs an economic activity that is able to generate income. However, a combination of conservation and production could be possible as discussed above. The key for impact investors is to see a positive impact on biodiversity not as an externality, but as a social and environmental return on investment.

7.2 Reflection on research

This study excels in combining science with practical insights. Overall, criteria and indicators are based on scientific literature while expert interviews put this in the specific context of impact investments in the forest sector. Moreover, this study contributes to research on the operationalisation of social-ecological resilience thinking (González-Quintero & Avila-Foucat, 2019; Schmitt-harsh & Mincey, 2020). Other research has mainly focussed on social-ecological resilience in for example coastal, agricultural or urban systems (e.g. Borgström et al., 2021; Ferro-Azcona et al., 2019; Panpakdee et al., 2021) while this study advances social-ecological resilience particularly in forest systems (Nikinmaa et al., 2023).

Though, a few considerations regarding this study should be discussed. First of all, this study acted on the belief that private sector investments in the forest sector can be a meaningful contribution to biodiversity conservation. All interviewees were involved in investing or forest project development through a market-based approach (e.g. carbon credits). This means that they generally have a positive attitude towards impact investments in the forest sector. This is not to say that people were not critical of certain practices and able to point out the pitfalls but they were generally positive about investing in forests and payment for ecosystem services. As such this study is not blind to contrasting views on the role of forests and synergies or trade-offs with the private sector (Begemann et al., 2023; Winkel et al., 2021) but provides a solution-oriented approach to tackle urgent needs in biodiversity finance while meeting global demands for wood products. We should be able to strike a balance between critical examination of options and taking action given the urgent need for solutions to the biodiversity crisis.

Following the investment perspective and the selected fund and companies as test cases is a potential bias towards plantation forestry. Even though some interviewees were also involved in other

types of silvicultural systems such as mixed and continuous cover forestry systems, the example companies used plantation systems. Investors are often also drawn to plantations as they are more attractive from a financial standpoint since higher financial returns can be achieved with a plantation (Form International, personal communication, October 12, 2022). The reader should be aware that there can be differences for implementation of the framework depending on the forest type. For example, trials with native species and mixed stands (indicator 24) may be more important to plantations as these often are the exact opposite (exotic monocultures). More natural forests with selective systems often already contain, though not exclusively, different indigenous tree species. Similarly, establishing areas for conservation (indicator 1.3) may be more difficult in a selective logging systems as harvest volumes are already lower than in plantations while further reducing the productive area may compromise the financial feasibility. This means that the framework is applicable in many different situations but that some indicators can be more relevant depending on the context.

A consideration regarding implementation of the framework is its broad geographical scope. This allows for wide application and offer flexibility in implementing the framework in the specific context or situation in which a company/project operates. Since the framework is intended to be applicable around the globe, large variation in local contexts will occur. For example the indicator on indigenous peoples is not as relevant in Germany as it would be in Brazil. Rather than being a one-size-fits-all for impact investments in forestry, it serves more as a guideline to investors in their due diligence process. The framework should always be tailored to the local context and allow the company or investor to in-/exclude certain criteria or indicators based on the context. Investors should also be aware that is not their role to demand specific operational details. It is up to the company/forest manager to define what the most suitable silvicultural system or monitoring method is. That is not the investor's responsibility and expertise. Rather, investors should require a management plan of sufficient quality that is credible and transparent. This will still require a level of expertise and qualitative assessment by the investors. However, by aligning reporting with internationally recognised standards (e.g. IFC Performance Standards, IRIS+) communication and assessment can be facilitated.

8 Conclusion and recommendations

This research project intended to aid in the mainstreaming of biodiversity in impact investments in the forest sector. The findings, specifically the impact framework, should offer guidance on the integration of biodiversity in investments and building social-ecological resilience. Impact investors already invest in forests for carbon sequestration, the next step for them should be to embrace biodiversity. In the end, boosting overall resilience with a stronger focus on biodiversity should bring greater benefits to society and the environment.

The impact framework presented in this report (Chapter 5) provides practical recommendations on how impact investors can shift their focus more towards biodiversity by adopting a social-ecological resilience approach. These recommendations take shape in the form of 20 criteria linked to 31 indicators that were obtained from a literature survey and expert interviews. Experts helped to put the framework in the specific context of impact investing in the forest sector. They highlighted the importance of certification (e.g. FSC, PEFC) or reporting standards (e.g. IFC Performance Standards) for maintaining quality, credibility and transparency. Experts also discussed an explicit focus on and ways to create positive and additional impact that is a key aspect of impact investments. Examples dealt mainly with forest management decisions such as species selection and silvicultural systems that promote higher levels of biodiversity.

Analysis of two forestry companies showed that impact investments cover many of the indicators in the framework. However, current reporting does not facilitate analysis by investors based on the framework. Some information is partially, or not, included in the documents. This highlights the role for investees (funds/companies/projects) to tailor their reporting to the analysis of investors. The responsibility of investors would be to raise questions about biodiversity impact for which the criteria and indicators in the framework can provide some inspiration. Furthermore, impact investments do not show great consideration of a social-ecological resilience approach. Addressing this shortcoming may be a way for investors and investees to combine risks and impacts while advancing impact investing in the forest sector in general.

By implementing this framework, and continually working on its improvement, biodiversity impact can be made more tangible. At the same time, it may encourage other investors to become impact investors and invest for biodiversity as they are now shown how this is possible. In the end, there seems not to be a lack of financial resources or willingness to invest in forests and contribute to biodiversity conservation but a need for attractive investments that clearly show additionality and speak to investors.

8.1 Recommendations

Impact framework

To advance the impact framework and impact investments in the forest sector, several following steps are recommended. The first would be to apply the impact framework in different settings. Testing the framework in different geographical and political contexts may provide new insight and feedback for the framework. Similarly, the framework may also be tested on different funds and companies with different approaches to forest management. This could include selective or continuous cover forestry systems. Other examples are forest projects focussed less on timber production and more on the sales of carbon credits, agroforestry products or NTFPs.

Following up on the development of the framework itself is its practical implementation. For this, a scoring system would be required that allows investors to compare potential investments. A useful way could be to develop a traffic light system that scores a company/fund as performing sufficient/good (green), partially sufficient/poor (orange) or insufficient (red). That way, potential investees can be graded based on these three categories. This requires guidelines on when exactly a potential investment scores sufficient, partially sufficient or insufficient. Defining these guidelines is highly recommended for future research. This may be done through organising workshops with scientists, investors and people at investment funds or forest companies. This interdisciplinary setting can provide insights, supported by science, on what is possible and verifiable in practice.

An addition could be to define which indicators are essential and which ones could be optional. This would result in a selection of 'need-to-haves' and 'nice to haves'. Indicators marked as need-to-have would then be considered the minimum requirement for a fund/company to be considered by an investor. The indicators marked as nice-to-have could show additional strengths and benefits of the fund/company over others that would make it more attractive for investors who are looking to maximise the impact of their investment.

A spider chart or radar chart could be used as visual presentation of where the main differences between potential investments are. Each criterium or indicator from the framework could be put one of the radial axes. Adding the scores from different potential investments on the chart would show strengths and weaknesses of each potential investment and differences between them.

Impact investing

Overall, the impact investing market should continue its work towards a common understanding of impact investing. A common definition of impact investments does not necessarily mean there is a common *understanding*. There can be different interpretations of what something like additionality means and how it can be achieved. For example, a recent study has shown that many 'sustainable investments' (SFDR article 9 funds) still invest in fossil fuels (see www.ftm.eu/green-investments). Many pointed towards the ambiguity of the term sustainable investments and EU regulations. However, such issues need to be overcome if investments are going to maintain their credibility and make real, positive social and environmental impacts. It is up to the fund managers and portfolio companies to align their policies and reporting documents with the impact framework. This will contribute to bridging the gap between investors and investees.

In addition, there is an important role for policymakers and the public sector to embrace the impact investing philosophy and integrate biodiversity (Wessemius-Chibrac et al., 2022). Policymakers should facilitate impact investing and foster a shift towards more impact focussed investments, rather than financial returns only. The new Sustainable Finance Disclosure Regulation (SFDR) in the EU may already be an important step in that direction. The framework presented in this report may serve as an example and inspiration for other initiatives to advance the consideration of biodiversity impact in investing.

Similarly, individuals can contribute by being critical and selective of where they put their money. Individuals can choose financial institutions (e.g. insurance companies, banks and pension funds) with better or more ambitious policies. People with investment accounts can directly invest in funds that have explicit impact targets.

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Appendices

A: List of papers included in the final database of the literature survey

No.	First author	Year	Title
1	Rölfer	2022	Resilience and coastal governance: knowledge and navigation between stability and transformation
2	Panpakdee	2022	Using the Delphi method to develop the social-ecological resilience indicators of organic rice production in Thailand
3	Prosperi	2022	Adaptive business arrangements and the creation of social capital: Towards small-scale fisheries resilience in different European geographical areas
4	Xiao	2021	Coupling and coordination of coal mining intensity and social-ecological resilience in China
5	Wieland	2021	Two perspectives on supply chain resilience
6	Stotten	2021	Social-ecological resilience in remote mountain communities: toward a novel framework for an interdisciplinary investigation
7	Panpakdee	2021	Assessing the Social-ecological Resilience of Organic Farmers in Chiang Mai Province, Thailand
8	Perrin	2021	Driving factors behind subjective resilience on organic dairy sheep farms
9	Sellberg	2021	Engaging with complexity in resilience practice
10	Borgström	2021	Retaining multi-functionality in a rapidly changing urban landscape: insights from a participatory, resilience thinking process in Stockholm, Sweden
11	Panpakdee	2021	Does the COVID-19 pandemic affect social-ecological resilience of organic rice production system in Chiang Mai Province, Thailand?
12	Zamora-Maldonado	2021	Social-ecological Resilience Modeling: Water Stress Effects in the Bighorn Sheep Management System in Baja California Sur, Mexico
13	Beachamp	2020	Twenty priorities for future social-ecological research on climate resilience
14	Nikinmaa	2020	Reviewing the use of resilience concepts in forest sciences
15	Burgess	2020	Assessing the assessment: An examination of resilience tools in water resource management
16	Ungar	2020	Social-ecological resilience through a biocultural lens: A participatory methodology to support global targets and local priorities
17	Kutzner	2019	Environmental change, resilience, and adaptation in nature-based tourism: conceptualizing the social-ecological resilience of birdwatching tour operations
18	Cheer	2019	Tourism and community resilience in the Anthropocene: accentuating temporal overtourism
19	Bomhauer-Beins	2019	When Culture Materializes: Societal Dynamics in Resilience of Social-Ecological Systems in the Case of Conch Management on Abaco, The Bahamas
20	Salomon	2019	Measuring social-ecological resilience reveals opportunities for transforming environmental governance
21	Panpakdee	2018	Indicators for assessing social-ecological resilience: A case study of organic rice production in northern Thailand
22	Cao	2018	Comparison of social-ecological resilience between two grassland management patterns driven by grassland land contract policy in the Maqu, Qinghai-Tibetan Plateau

23	Arnold	2018	Resilience of the Anacostia River Basin: Institutional, Social, and Ecological Dynamics
24	Cosens	2018	Social-Ecological Resilience in the Columbia River Basin: The Role of Law and Governance
25	Ashkenazy	2018	Operationalising resilience in farms and rural regions e Findings from fourteen case studies
26	Suroso	2018	Social-ecological resilience for the spatial planning process using a system dynamics model: case study of Northern Bandung area, Indonesia
27	Allen	2018	Quantifying uncertainty and trade-offs in resilience assessments
28	Caillon	2017	Moving beyond the human-nature dichotomy through biocultural approaches: including ecological well-being in resilience indicators
29	Trell	2017	Governing for resilience in vulnerable places: An introduction

B: List of interview organisations

Interview	Organisation	Type	Country
1	ASN Bank	Commercial bank/advisor	Netherlands
	ASN Impact Investors	Investor	Netherlands
2	FMO	Investor/development bank	Netherlands
3	SLM partners (SLM Silva Fund)	Fund manager	Ireland
4	Form International	Advisor/developer	Netherlands
5	Face the Future	Advisor/developer	Netherlands
6	Generation Forest Invest (previously Arboreal)	Developer/investment manager	Netherlands
7	Treevive	Developer	Netherlands
8	Independent consultant	Advisor	Netherlands

C: Interview topic list and guiding questions

Topic list

- Definition/understanding of biodiversity and impact investing
    - Intentionality
    - Additionality
    - Measurement
- Threats or risks to forests and biodiversity
    - Environmental
    - Social
    - Financial
- Solutions to the identified threats
    - Manage diversity
    - Manage connectivity
    - Manage slow variables
    - Dealing with complexity (complex adaptive systems)
- Monitoring & evaluation
    - Inventory
    - What data is needed?
    - How can it be measured?
    - Thresholds (slow variables and feedbacks)
- Learning/knowledge sharing
- Participation
    - Organisations
    - Stakeholders (build trust and legitimacy)
- Decision making processes (polycentric governance)
    - Investors
    - Local stakeholders
    - Other institutions (scientific, government etc.)

Guiding questions

Topic	Questions
Introduction	1. Can you explain, in your own words, what your organisation does and what is your role is?
Definitions	2. What is your understanding or definition of biodiversity? 3. And that of impact investing? a. How does it differ from for example ESG investing?
Threats and priorities	4. What do you perceive as the main threats to: a. Forests b. Biodiversity c. Livelihoods d. Finance / businesses 5. Should certain areas / species be prioritised? a. Threatened/red list species b. Endemic species (species that live nowhere else; e.g. koala) c. Biodiversity hotspots d. Spiritual areas e. Financial argument? (cheaper land, faster growth in tropics)
Solutions, criteria	6. What should forest companies/managers do to tackle the threats? a. Certification? 7. How can you have both positive financial returns, and a positive impact on society and the environment? a. Balance/trade-off (conservation vs production) b. Sources of income (beyond carbon credits/timber?)
Indicators, measurement	8. What are key elements that potential investments should have (or you look for), that indicate positive impact? a. How to measure (criteria + indicators) b. Before investing; due diligence c. To assess financial risk/resilience 9. What would have to be monitored? a. Feedback loops
Learning	10. How do you process new insights/information? a. Who do you share/work with?
Participation	11. How should investors engage with investment funds/companies? a. Additionality of impact investors 12. How can all stakeholders be involved?
Decision making processes	13. Who are, or should be, involved in decision making processes? o And to what extent? o Investors o Local stakeholders (land acquisition) o Other institutions (scientific, government, consultancy etc.)
	14. Is there anything else you would like to mention?

D: Background information about the author

In the description below, the author briefly describes his own background.

I am a Dutch male of 24 years old, living in a small village in the eastern, rural part of the Netherlands. I hold a BSc in Forest & Nature Management with a specialisation in Tropical Forestry. As part of my MSc in Forest and Nature Conservation I have completed a combination of courses on ecology, society and economics. Examples of courses include 'Forest Ecology and Forest Management', 'Communities, Conservation & Development' and 'Environmental Economics for Environmental Sciences'.

I have a personal interest in finance and investing and am a small retail investor. However, I am not invested in one of the funds discussed in this study. The combination of my interest in finance/economics and forest management led to the selection of the topic (impact investments in the forest sector).

During the course of this thesis process I have been in close contact with people at ASN Impact Investors and ASN Bank. This has given me practical insights in the work of an impact investor. At the same time, this will have shaped my view on (impact) investing. In particular, I have become more familiar with the ASN Biodiversity Fund (*ASN Biodiversiteitsfonds*). My understanding of impact investments in the forest sector is therefore largely based on this fund.

I have also witnessed webinars and live events dealing with topics related to this study. While this contributed to my understanding of the finance sector or impact investing specifically, this will have shaped my views and attitudes towards those.

E: Table of all the operationalisation of resilience principles in literature

Total number of entries used (n) and percentage of publications (%) per resilience principle are given.

SES resilience principles	Examples of operationalisation (all unique entries)	n	%
Maintain diversity and redundancy	restoration, natural capital, nurturing diversity, biodiversification, conservation activities, invasive species control, establishing protected areas, water sources availability, maintaining natural vegetation, ecosystem restoration, biological diversity, ecological variability, ecosystem services	45	41
Manage connectivity	mobility, modularity, facilitating dialogue and building networks between different actors, social capital, relationships, marketing, building relations between science and practice and integrating different disciplines and types of knowledge, bridging organisations, cross-scale linkages, optimising the use of public support, proximity to city, government support, institutional arrangements, travel corridors, bridge differences in terminology, social network and support, increasing cohesion between different social groups, synergise restoration and development, mapping social networks and governance relationships, building networks, urban-rural residents relations, cooperative networks, farmer associations	33	52
Manage slow variables and feedback	understanding feedbacks between social and ecological processes, preparation for unpredictable events, long-term monitoring, ecosystem-based approaches, considering potential thresholds of concern and possible regime shifts, explore underlying causes of shocks, identifying historical changes and trends, tight feedbacks (responses), understand (changes in) migration patterns, invest in risk management, reconcile engineering and ecosystem function, monitoring plan, identification of key system thresholds, understand feedback between agriculture and other impacts, ecosystem-based management, consider historic context, identifying external drivers of change and interactions across scales, remain within planetary boundaries, conceptualizing and modelling system interactions and feedbacks, understanding dynamics of diseases, explore underlying deficiencies in the system, monitoring	27	48
Foster Complex Adaptive Systems thinking	adaptive management approach, moving beyond-human nature dichotomy, highlighting and conceptualizing connections between people and the biosphere, living with change and uncertainty, acknowledge uncertain future conditions, asses the 6 features of CAS, understand communities' dependency on and use of the environment, acknowledging slow variables, allowing for emergence through trust-building and a flexible process, identifying system components and their relationships, quantification of relationships between system properties, include risk and uncertainty, participatory scenario planning, open to change, integrating ecosystem and human well-being, supply chain as CAS, developing alternative future scenarios and pathways, building adaptive	32	59

	management, long-term climate change adaptation, adaptive co-management, using theory-based resilience assessment framework		
Encourage learning and experimentation	reorganisation, interdisciplinary research, willing to learn, knowledge sharing, development, iteratives processes, enhancing system understanding among participants, combining types of knowledge, adaptive capacities, time availability, experimentation, acquiring knowledge building capacity of external actors in planning, monitoring and learning, building a learning culture, designing a flexible and iterative process, open-minded, active learning, communication, disturbance as window of opportunity, favourable learning environment, sharing of scientific resources, cultural transmissions, participatory scenario planning, local traditional knowledge, adaptive co-management, shaping a learning environment, tourist education, expert and public learning, implement lessons from monitoring in actions and decisions, innovation, learning between levels of government and across state, market and civil society, technological innovation	40	59
Broaden participation	consider the relevance of local values and experiences, integrating traditional knowledge into the monitoring and management process, translate and adapt the process and issues to the local context and actors, accountable actors, defining (un)desirable states, bottom-up approach, opportunities for self-organization, combining types of knowledge, local participation, bringing actors together to develop coordinated actions, knowledge co-production, supporting social learning and dialogue, involve stakeholders in the model validation as well as in scenario construction, stakeholder participation, enabling the creation of (multiple and/or shared) narratives, ecosystems as stakeholders, consider multiple values and definitions of the system, public participation in scientific research (PPSR), self-organisation, participatory stakeholder mapping, establishing a common vision, collective action, enabling a broader scope and reinforcing local perspectives, collaborative research, participatory monitoring, people leading resilience practice reflecting on their own roles in shaping outcomes, cooperation, engaging community in capacity building, joint planning activities, participatory continued adaptive management, participatory goal setting, participatory identification of locally relevant criteria and indicators of resilience, participatory monitoring, and evaluation, stakeholder engagement	45	45
Promote polycentric governance systems	adaptive governance system, asking the key question “resilience for whom and at what cost to which others?”, balance short-term and long-term measures, be aware of from whose perspective resilience is ‘done’, defining agency of actors, defining scale and boundaries for dealing with issues, engaging key higher levels of governance and external actors who shape system context and dynamics, establishing trust, finding a useful way of defining the boundaries of the focal system, flexible, innovative, and adaptive local management, foster social stability, identify what information is	32	48

	needed for decision making, identifying actors of the system of interest, imbedding feedback loops in governance processes, indigenous governments exerting traditional authority in access to resources, integration of Indigenous knowledge and stewardship protocols in management, leverage traditional and local knowledge, long-term approach, make use of windows of opportunity, measuring resilience across multiple scales, multi-scalar governance, navigating between stability vs transformability, overlap in governance, political capital, prioritise short- vs long-term management, reconcile local contextualised approaches with global dynamics and processes, risk & resilience management, set spatial and temporal boundaries, support equitable authority and shared power between federal and Indigenous managers, thoughtful of historic discrimination, understanding power dynamics		

F: Table of all the disturbances identified in the literature

	Stressors	**Shocks**
Biophysical	climate change, rising temperatures, ocean acidification, sea level rise, changed precipitation patterns, changed wind conditions, changed wave conditions, eutrophication, sedimentation, depleting stocks, overexploitation, mining, biodiversity loss, rising ocean temperature, habitat loss, habitat fragmentation, resource depletion, loss of intergenerational knowledge transmission, decreasing population size classes, extreme climatic variations, inbreeding, trampling, pollution, river engineering, fertilizers, pesticides, hydrological alterations, waterway damming	Earthquake, tsunami, hurricane, drought, volcanic eruption, bark beetle outbreak pest outbreak, late frost, predation, flooding, storms, El Niño, fire, landslides, diseases, pest outbreaks, freezing temperatures, hail, peak storm events
Socio-economic	population growth, economic development, urbanization, changed normative values, reducing labour availability, rising operational costs, growing competition, evolving regulatory frameworks, changing consumption patterns, new regulations, mining, changing consumer preferences, uncertain demand for product, infrastructure development, changing demography, prioritisation of funds, societal change, economic growth, mass tourism, amenity decline, overexploitation, illegal harvest, poaching, conflict of interest, lack of trust, communication problems, change in competition, geopolitical situation, accelerated transfer of land ownership	market instability, price volatility, pandemic, new regulations, financial crisis, delay in payments, policy change, sabotage, loss of iconic species, temporal overtourism, boycott