Make nature count

Integrating nature's values into decision-making

A pilot study: assessing expected changes in ecosystem services and the valuation of these changes in four different (ASN Bank) projects

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Abbreviations

ABC-Map Adaptation, Biodiversity and Carbon Mapping Tool
BFFI Biodiversity Footprint Financial Institutions
CBF Corporate Biodiversity Footprint
EDS Ecosystem Disservices
ESVD Ecosystem Services Valuation Database
FAO Food and Agriculture Organisation
GBS Global Biodiversity Score Footprinting
IBAT Integrated Biodiversity Assessment Tool
MSA Mean Species Abundance
NPV Net Present Value
PBAF Biodiversity Accounting Financials
PBL Planbureau voor de Leefomgeving
PDF Potentially Disappeared Fraction
TEV Total Economic Value
TNFD Taskforce on Nature-related Financial Disclosures

Definitions

Total Economic Value: The benefits/welfare effect of the sum of the ecosystem services provided by a particular ecosystem for a specific area annually.

Net Present Value: The TEV accounting for the time value of money based on the time horizon and the discount rate.

Foreword

ASN Bank has set itself the long term goal to have a net positive effect on biodiversity by 2030 as a result of all of the bank's loans and investments. With this goal, the bank wants to prevent any further loss of biodiversity and wants to contribute to a net gain in biodiversity. Progress towards this goal is monitored annually and a Biodiversity Fund has been developed to invest in biodiversity gain. But what does a positive effect on biodiversity actually mean from a societal perspective? Who benefits or loses from a (local) change in biodiversity?

Biodiversity underpins the provision of ecosystem services by ecosystems, like the provision of pollination services by an area that supports pollinators, such as honey bees. These ecosystem services may benefit certain stakeholders, such as farmers producing pollinator-dependent crops. Similarly, a forest that sequesters carbon will reduce climate change, benefiting society as a whole. In other words, a change in biodiversity may affect the provision of ecosystem services which may impact certain stakeholders. In many cases there will be both winners and losers because of ecosystem services trade-offs. For example, optimizing carbon sequestration through reforestation of an agricultural area may go at the cost of food production.

Understanding who wins and who loses as a result of changes in biodiversity is key from the perspective of stakeholder-support in areas where investments take place. Not just because projects will be more successful if the impacts on stakeholders are taken into account, but also because the estimated gains in biodiversity are more likely to be permanent if the effects are supported.

To gain a better understanding of the (potential) impacts of investments on ecosystem services and the value of these services to society and local stakeholders, ASN Bank has asked the Foundation for Sustainable Development (FSD) to assess the expected changes in ecosystem services for four different projects (case studies, some of which are part of the ASN Biodiversity Fund), and to assess the value of the ecosystem services affected, using the Ecosystem Services Valuation Database (ESVD).

The project does not yet provide all the answers where it comes to assessing changes in ecosystem services resulting from investments and the value of these services. However, it does provide a valuable first step to understand what data is needed to conduct such an assessment, the insights such an assessment provides to financial institutions and the follow-up steps needed to increase the accuracy and value of such an assessment. ASN Bank will use the results to discuss how these assessments can support the bank's decision-making in the area of biodiversity.

I would like to thank FSD for the great work they have done, Trees for All, ASN Impact Investors and SarVision for their input to the case studies and Wijnand Broer (CREM) and Caroline van Leenders (Netherlands Enterprise Agency, RVO) for their valuable feedback on the results.

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Executive summary

Ecosystems deliver a broad range of ecosystem services (ES) that underpin human well-being. The loss of biodiversity and degradation of ecosystems has an increasingly negative impact on society and businesses, including the financial sector. Through their investments, financial institutions can be heavily dependent on ecosystem services and deterioration of nature therefore causes risks for financial institutions: physical risks, transitional risks and reputational risks. Recently central banks also speak about systemic risks. Assessing the extent of the different risks requires insights in the impact of investments and loans on biodiversity as well as insights in the dependencies on nature, biodiversity and related ES. The concept of ES and their subsequent monetization helps to translate ecological information into economic and policy-relevant terms. Ecosystem services assessments are therefore important for a more inclusive impact- and dependency assessment of sustainable business models and financing.

To properly take the full value of nature into account in decision-making, reliable data on the economic importance and monetary value of ecosystem services is essential. The Ecosystem Services Valuation Database (ESVD) is the largest publicly available database with standardized monetary values of all ecosystems and their services. The ESVD can be used in risk assessments through providing data on the monetary value of ES of different land covers. Ideally, original data should be collected for each investment case. This is very time consuming and expensive but for a first estimate use can be made of existing data from similar cases (as provided for in the ESVD) through so-called benefit or value transfer approaches. To gain understanding of how monetary valuation data on ES can assist financial institutions in decision-making, we conducted rapid ES assessments, using the ESVD, to analyze biodiversity-related risks of four so-called “positive impact” projects (in the Netherlands, Madagascar, Paraguay and Nicaragua) which were provided by ASN Bank.

In this report we generated an overview per case study of:

1. The ecosystem services affected by a land cover change (identifying trade-offs between different services provided by diverse land covers).
2. The monetary value of these services through the TEV (which indicates the order of magnitude of the impact).
3. The accumulation of the Net Present Value (NPV) for a given time period (which indicates the needed adjustments in investment criteria and contract conditions).
4. The distribution of benefits and losses over the different ecosystem service categories (which also provides insights in which stakeholders could be influenced).

Based on the available data and acknowledging the short time span of these desk studies, we found that in all four cases the planned interventions had a positive effect on the total bundle of ecosystem services provided, and thus on the monetary value.

Using a time-span of 10 years and a discount rate of 5%, the NPV of reforesting agricultural land in the Netherlands (the Geelders case) increased from 17,500$/ha to approx. 31,000$/ha. For the reforestation project in Madagascar (converting 150 hectares of degraded pastures and shrubland into dryland forest) the increase in value was even more substantial: from a mere approx. 870$/ha now to over 50,000$/ha under the investment scenario.

The case study in Paraguay was somewhat complex: the aim of the investment is to convert most of the agricultural land in a concession area that also contained some wetland, Cerrado and natural forest into a eucalyptus plantation. The NPV of continuing the current situation was estimated at 35,000$/ha while the scenario with Eucalyptus increased the value only slightly to 39,000$/ha. Interestingly, our analysis showed that the total value of the ES in the natural part of the concession slightly decreased and that most of the value-gain came from the increased (market) value of Eucalyptus plantation.

This case highlighted the importance to make a distinction between market, usually private, values and so-called 'shadow prices' (indirect market values) for public benefits. Finally, the fourth case study analyzed the difference in Total Economic Value (TEV) between shaded coffee growing compared to conventional coffee plantations in Nicaragua. This case showed once more that investing in sustainable, multi-functional land use 'pays'. Not only in terms of environmental and societal benefits, but also economically: the TEV of the conventional coffee system was estimated at 4,700$/ha/year and of the shaded, agro-forestry system at approx. 5,800$/ha/year.

Of course, all these rather precise values must be interpreted with caution, especially because they are based on a short desk study using value transfer methods, but the outcome is consistent and shows that ES assessments provide important insights in the wider effects of land cover changes. Because our analysis uses the monetary values for all of the involved ecosystem services, it provides a more complete insight in both market values and shadow-prices, which pinpoints the direction of benefits and risks for businesses and society at large.

Conventional environmental assessments, which usually only account for ES traded in markets, miss important indirect non-market values of public services, such as effects on air-, water- and soil quality, natural pollinators, climate regulation, biodiversity protection and non-material benefits which also influence physical, transitional, reputational and eventually systemic risks for financial institutions.

Another important benefit of the ES-approach is that it helps to identify the distribution of benefits and losses over the different ES categories, looking beyond sole market values, and thereby providing insight in which stakeholders are impacted and should be involved in the planning and decision-making of investment projects.

Finally, in chapter 4 we integrated the ES-approach in the 'LEAP approach' (Locate, Evaluate, Assess, Prepare) of the TNFD Framework. It illustrated that a change in ecosystem services not only affects physical, transitional and reputational risks for the company and investors which are directly involved, but also for many other stakeholders surrounding the investment location.

Ultimately, the 'true value' of ecosystems and their services should be structurally integrated in the economic and financing system if we want to stop the continuing loss and degradation of ecosystems and biodiversity. As was recently stated by Frans Timmermans (Vice President of the European Commission) in his speech introducing the new Nature Restoration Law on 22 June 2022: *"Investment into nature restoration adds €8 to €38 in economic value for every €1 spent, thanks to the ecosystem services that support food security, ecosystem and climate resilience and mitigation, and human health".*

This report illustrates this statement. It shows how the ESVD can help provide the much-needed data to put all ecosystem services on the balance, how this influences time horizons and the involvement of various stakeholders. In this report we make nature count in a more complete way, and in doing so it supports better informed, more sustainable decision-making processes.

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1 Introduction

1.1 LOSS OF BIODIVERSITY AND ITS RISK TO FINANCIAL INSTITUTIONS

Loss of biodiversity is continuing globally at an alarming rate. The Living Planet Report of WWF (2020), concluded that *"Due to over-exploitation of ecological resources by humanity, populations of fish, mammals, reptiles and amphibians have decreased with 68% from 1970 to 2016, 75% of the land surface has substantially been altered."*

The Dasgupta review, Nature's worth to society (2021), elaborated on the roots of this problem:

"The true value of the various goods and services it [nature] provides, is not reflected in market prices because much of it is open to all at no monetary charge. These pricing distortions have led us to invest relatively more in other assets, such as produced capital, and underinvest in our natural assets.
Moreover, aspects of nature are mobile; some are invisible, such as in the soils; and many are silent. These features mean that the effects of many of our actions on ourselves and others, including our descendants, are hard to trace and go unaccounted for, giving rise to widespread 'externalities' and making it hard for markets to function well."

As a consequence of not taking the full value of nature into account, the loss of biodiversity has an increasingly negative impact on society and businesses, including the financial sector. The Dutch Central Bank and the PBL (the Netherlands Environmental Assessment Agency), assessed the risk the Dutch financial sector is facing in their report "Indebted to nature" (Van Oorschot & Kok, 2020). In this report, they show that Dutch financial institutions worldwide have EUR 510 billion in exposure through companies with high dependency on one or more ecosystem services.

BOX 1: MAIN ECOSYSTEM SERVICES TYPES (CATEGORIES) AND THEIR DEFINITION

Ecosystem services are defined as "the direct and indirect contributions of ecosystems (biodiversity and nature), to human wellbeing" and comprise the following four main categories:

- Provisioning services are the products or resources that can be harvested or extracted from ecosystems (e.g., food and raw materials).
- Regulating services are the benefits obtained from ecosystem processes that maintain environmental conditions beneficial to individuals and society (e.g., climate regulation, air quality, flood protection, biological control, pollination).
- Habitat services are the benefits provided by protecting a minimum area of natural ecosystems to allow evolutionary processes needed to maintain a healthy gene pool and by providing essential space in the life cycle of migratory species, many of which have commercial value elsewhere (notably the nursery service of mangroves and other coastal systems).
- Cultural services are the experiential and intangible benefits related to the perceived or actual qualities of ecosystems (e.g., spiritual enrichment, cognitive development, recreation, aesthetic enjoyment, and the appreciation of the existence of diverse habitats and species).

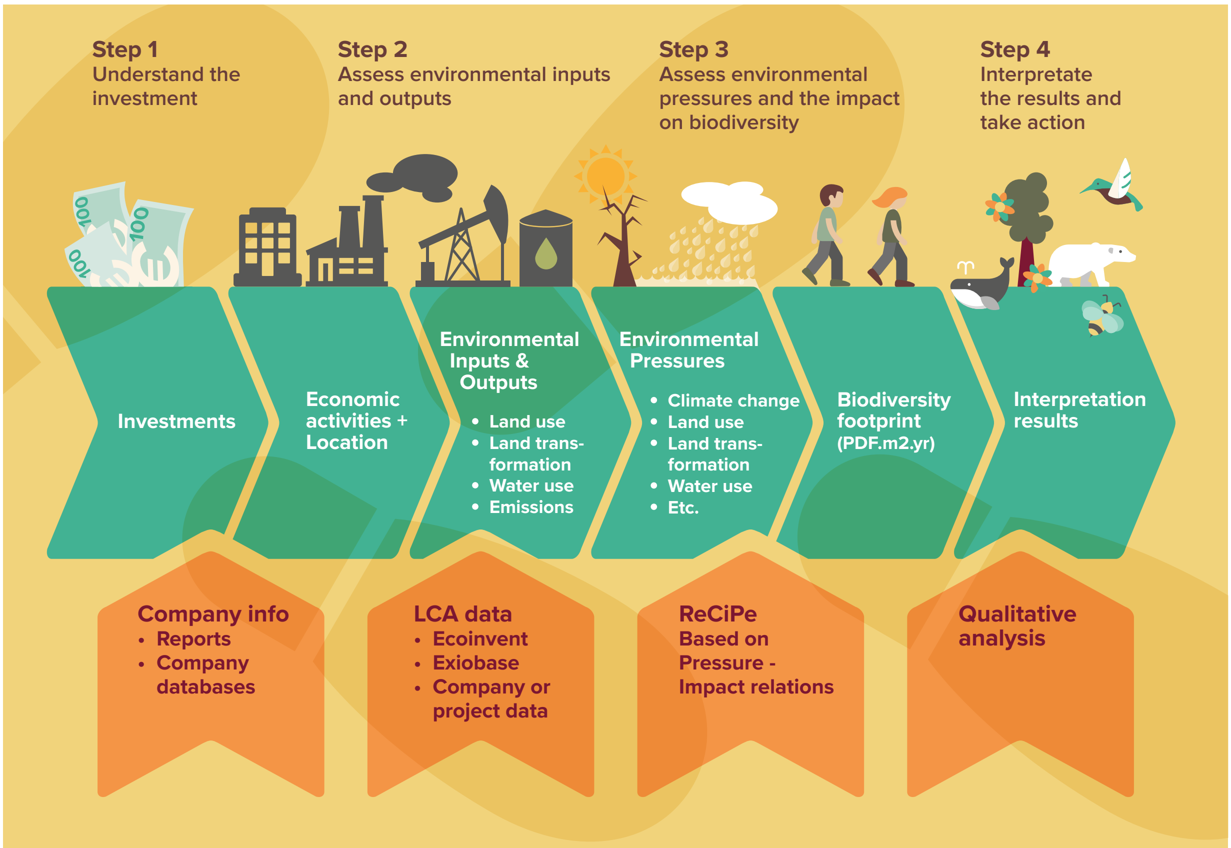
Van Oorschot & Kok (2020) distinguished three types of risks: physical risks, transitional risks and reputational risks. The investments are subject to physical risks if the natural systems are less able to provide the services that the business depends on, whereby the deterioration of biodiversity and the reduction in ecosystem service provision is often caused by the activities of the companies themselves. Furthermore, financial institutions run reputational risks when they finance companies that have a (major) negative impact on biodiversity. Sometimes these reputational risks can also be seen as a pre-cursor for regulation, which feeds into transitional risks. Transitional risks are risks financial institutions are facing because of changing laws and regulations in response to decreasing biodiversity and possibly a decrease in ecosystem service provision. Additionally in the last years Central banks added the category of systemic risk. Acknowledging the risk that when one ecosystem or a significant amount of services within this ecosystem collapses it's influence reaches beyond the project border and thereby potentially impacts investments that are miles away.

1.2 PROGRESS IN ASSESSING IMPACT AND DEPENDENCIES OF FINANCIAL INSTITUTIONS ON BIODIVERSITY

Assessing the extent of the different risks requires insight in the impact of investments and loans on biodiversity as well as insights in the dependencies on nature and biodiversity. In the past years important steps have been made in assessing these impacts. The Dutch ASN Bank is one of the leading organizations in this field. The ambition of ASN Bank is to have a net positive effect on biodiversity as a result of all of their loans and investments by 2030 (ASN Bank, n.d.). They aim to invest in wildlife conservation, sustainable energy and in circular economy. Through contributing more to nature than taking from it, the ASN Bank focuses on achieving a net positive impact, meanwhile realizing that netting negative and positive impacts is not acceptable from a biodiversity and ecosystem services point of view. From that viewpoint, the objective of reaching a 'net gain' must be seen as an aspirational goal triggering action.

To achieve this goal and to get a better insight in their impact on biodiversity, ASN Bank developed, together with CREM and PRé Sustainability, the Biodiversity Footprint Financial Institutions (BFFI) foot printing methodology to assess impacts on biodiversity of loans and investments (see Figure 1). Moreover, the Partnership for Biodiversity Accounting Financials (PBAF) was initiated by several financial institutions in 2019 to develop a sector standard for biodiversity impact and dependency assessment. (PBAF Netherlands, Paving the way towards a harmonized biodiversity accounting approach for the financial sector, September 2020.).

Figure 1: Biodiversity Impact assessment steps in the Biodiversity Footprint Financial Institutions (ASN Bank, 2019)



Using the BFFI methodology, financial institutions can assess impacts on biodiversity at a portfolio, sector, company and project level. The methodology is based on pressure-impact modeling and can only take into account a limited number of location specific characteristics. The impact is expressed as the Potentially Disappeared Fraction (PDF) of species per ha, during a specific time as a result of the impact drivers (such as land cover change and climate change) induced by environmental pressures (like emissions of greenhouse gasses). However, a more detailed assessment of the impacts and dependencies on biodiversity requires a broader approach, looking beyond species only, taking into account the whole ecosystem perspective. Furthermore, more detailed information on the impact location/area is required to better determine the potential impact of the various drivers on biodiversity.

The need for applying a holistic ecosystem-level and location-specific view is also recognized by the Taskforce on Nature-related Financial Disclosures (TNFD). In March 2022, the TNFD presented a risk management and disclosure framework (TNFD, 2022) for organizations to report and act on evolving nature-related risks. This framework puts location and ecosystem services at the center of risk and impact assessments. Their ultimate aim is to support a shift in global financial flows away from nature- negative outcomes and toward nature-positive outcomes. The TNFD framework provides fundamental concepts and definitions regarding nature. It also provides draft disclosure recommendations for nature-related risks and opportunities. Finally, it provides guidance for corporates and financial institutions to undertake nature-related risk and opportunity assessment and incorporate this into their enterprise strategy and risk management processes to inform a range of corporate and capital allocation decisions, including those relating to reporting and disclosure.

From the above it is clear that the location-based integrated Ecosystem Services Assessment-approach should be an essential element in all attempts to come to a more inclusive impact and dependency assessment of sustainable business models and financing. Only by taking the full perspective of an ecosystem and it's location-specifics into account we can get a clear and true insight in the impact and dependencies of the investment.

1.3 ECOSYSTEM SERVICE VALUATION DATABASE (ESVD) AND SATELLITE INFORMATION

1.3.1 Introduction

The importance of ecosystem services is acknowledged, implicit and explicit in all above-mentioned assessment methodologies. The concept highlights the dependence of societies and economies on ecosystems, and their contribution to human welfare in general. Ecosystem services and their subsequent monetization helps to translate ecological information into economic and policy-relatable terms. A better understanding of the monetary value of ecosystem services allows relevant stakeholders to speak a common language and come to better informed decisions (see box 2 for the broader context of monetization). The valuation of ecosystem services is also relevant because it provides a comprehensive and structured overview of the (potential) gains and losses to individuals and society as a result of changes in biodiversity and ecosystems.

However, assessing and quantifying changes in ecosystem services and their monetary value due to the impact of land cover changes and/or changes in biodiversity is labor intensive, costly and empirical data is not easily available.

1.3.2 Development of databases, methodologies and techniques

In the past few years, new methodologies and techniques have been developed to more easily assess and quantify location-specific changes in biodiversity, the ecosystem services that are (potentially) provided, as well as the monetary value of these services. For example, location-specific changes in biodiversity and ecosystems can now more easily be extracted from satellite data. New tools like the Adaptation, Biodiversity and Carbon Mapping Tool (ABC-Map) of the Food and Agriculture Organisation (FAO) allow users to select any place on earth and calculate changes of land cover since 1992. The tool also assesses changes in biodiversity based on a series of pressure indicators, determines observed climate change (temperature and precipitation) since 1992 and assesses changes in carbon stocks. Satellite companies such as SarVision are developing methodologies based on radar imaging to analyze biodiversity disturbance by measuring changes in vegetation composition and vegetation structure.

BOX 2: THE VALUE OF VALUING NATURE

To measure the 'true value' of nature in monetary terms is by definition impossible but the cost of not taking the value of nature into account in every day decision-making is huge. After 25 years of development in the field of valuing ecosystems, Daily and Ruckelshaus (2022) published an overview in the Journal 'Nature' of how these valuations advanced since then and what the value of monetization proved to be:
"A quarter of a century ago, Costanza et al. put forward an estimate for the economic value of global ecosystem services. The authors valued these at US$33 trillion per year. Objections to the exercise were raised on many grounds, from those involving technical matters to ethical concerns about pricing nature. Yet Costanza and colleagues' bigger aim went far beyond merely producing a number. They wanted to reframe the way people think about nature, especially in the context of economic decision-making." All the other efforts that were being made until that point *"highlighted key elements of what needed to change, and addressed how fast*

and why the alterations were necessary. But a burning question remained largely unanswered: how to move from knowledge to action." With the introduction of monetary valuation of ecosystem services, the change in economic and financial decision making could be made. Governments and local communities started to include nature in decision-making for example through developing Payment for Ecosystem Services (PES) schemes, or redirected funding towards an ecological approach on problem solving. *"The many efforts to value ecosystem services help to advance this kind of funding for nature beyond the usual kind, provided by philanthropy."* (Daily and Ruckelshaus, 2022)

1.3.3 Monetary data: The ESVD

To facilitate assessing the impact of changes in biodiversity on ecosystem services in monetary terms, the Ecosystem Services Valuation Database (ESVD, www.esvd.info) was developed. Work on the ESVD started in 2008 as a contribution to the TEEB-study (www.teebweb.org) and the ESVD is currently the largest publicly available database with standardized monetary values in dollars per hectare per year in a given year, corrected for inflation for all ecosystem services and all biomes on all continents. The ESVD now contains over 8,000 value records from over 1000 studies and new values are added continuously. With the ESVD, the annual monetary value of individual ecosystem services can relatively easily be translated into a Total Economic Value (TEV), symbolizing the maximum potential sustainable total flow of ecosystem services for an ecosystem or area per year. To analyze the net-benefits (or costs) of an investment, it is important to have information about the (net) present value of the future benefits (or costs) of the project. With data from the ESVD, the Net Present Value (NPV) of an ecosystem can be calculated relatively easily for different scenarios of change in biodiversity using projections of the changes in TEV (resulting from changes in flows of ecosystem services) over a given time period at a certain discount rate (see chapter 2.1 for more detail).

1.3.4 Use(r)s of the ESVD

With data from the ESVD, the monetary value of ES can be calculated relatively quickly for use in impact assessments and integrated Cost Benefit Analyses, and thereby contribute to better informed decision making by a variety of stakeholder groups such as:

International Governmental Organizations: With the impact of climate change, land degradation and biodiversity loss becoming increasingly visible, organizations like FAO, IPCC, UNEP and others are in need of data on the real societal costs of these environmental problems as well as the economic benefits of investing in prevention, mitigation and adaptation.

Governments (local, regional national and supra-national decision-making bodies): At all levels of public decision making, similar questions as those mentioned above) are relevant but in addition, national, regional and local issues are in need of better data on consequences of programs and projects that affect specific landscapes and ecosystems.

Financial sector: To support the transition to a 'greener economy', the financial sector is crucial. The loss of biodiversity increasingly impacts society and businesses, including the financial sector. In March 2022 the Taskforce Nature related Financial Disclosure published a report in which they underpin the importance of Ecosystem services in measuring and reporting on biodiversity risks.

Business sector and consultants: The business community is increasingly willing to change their business model into a more sustainable direction and internalize the (negative and positive) externalities.

NGO's: An important function of NGO's is to critically follow the actions of governments and their effects on the environment and human wellbeing and take the role as 'frontrunner' to implement new ideas into practice and show that it can work.

See www.esvd.info for further information and examples of users and practical applications of ESVD.

1.4 OBJECTIVES

Although the above-mentioned new tools and technologies provide a wealth of new insights, their practical use to help financial organizations to better assess the biodiversity-related risks of specific projects or companies they invest in or their whole investment portfolio is limited due to lack of monetary and financial data.
This project therefore aims to achieve the following objectives:

1. Use the ESVD to determine the impact of land cover changes on ecosystem services and their monetary value in four selected case studies.
2. Explore the use of satellite data in biodiversity impact assessments to determine the extent of land cover change that took place in a given time period.
3. Explore how to combine satellite and the ESVD data with existing methodologies such as Biodiversity Footprint for Financial Institutions (BFFI) and the Taskforce on Nature-related Financial Disclosures (TNFD).
4. Gain understanding of how to use this knowledge to assess biodiversity-related risks for financial investments.

Chapter 2 provides an overview of the methodology applied. Chapter 3 presents examples of the assessment of ecosystem services and their monetary value as a result of different land use change scenarios for four different biodiversity positive investment case studies. Chapter 4 explains how the ESVD can be used to better assess biodiversity-related risks for financial investments and Chapter 5 presents the conclusions and recommendations. Appendix 1 gives an insight in the ‘black box’ of the assessment by providing background remarks for case study 1 as example of the calculation of the TEV and NPV. Appendix 2 provides more information on the different ecosystem services.

2 Methodology

2.1 SELECTION OF CASESTUDIES

In this project, the changes in monetary values of ecosystem services as a result of land cover changes were assessed and these changes in values were integrated into a preliminary risk profile. This risk profile pinpoints which risks for financial institutions intertwine with changes in the provisioning of ecosystem services.

The following four case studies were included in the assessment:

1. Reforestation in the Geelders, the Netherlands (obtained from Trees for All)
2. Reforestation in Zazamalala, Madagascar (obtained from Trees for All).
3. Investment in a eucalyptus plantation in Paraguay.
4. Comparison of a shade-grown coffee system with a conventional coffee system, Nicaragua.

The selection criteria for these cases were the following:
- Availability of information on the land cover categories and condition before and after the project. Preferably internationally accepted natural land cover categories, such as the IUCN Global Ecosystem Typology, were used. Other descriptions of land cover were also found suitable. The description should be as detailed as possible, preferably at the ecosystem level. A description of land cover that only includes the term 'forest' is not sufficient because it is not specific enough.
- Availability of information on the specific location where the land cover change took or will take place, specifically the location and ownership of the area. This allows for determining, among other things, the type of ecosystem when this is not described, such as in case studies 3 and 4. The provisioning of ecosystem services and therefore the flow of benefits provided is very context specific, therefore information on the location is very important. This criterion allows for a better assessment of the impacts and dependencies of investments on ecosystems and associated ecosystem services.

The case study selection process provided us with insights in the information required to perform the assessment on the changes in ecosystem services and their monetary value (Chapter 3) as well as a first translation into risks (Chapter 4).

For each case study, we applied the same assessment procedure to determine the monetary value of ecosystem services affected. The procedure consists of four steps. Each step is explained below.

Step 1: Understanding and describing the context of the case study and determining the different land cover change scenarios

The goal of step 1 is to understand the context of the case studies and to extract the relevant project information provided by the company or financial institution. Based on the data provided, we developed two different land cover scenarios. For each case study, the baseline scenario assumes no change in current land cover. The second scenario describes the changes in land cover that are expected to take place due to the investment. The more detailed and location-specific the information, the more detailed the different land cover scenarios could be developed. The information of changes in land cover came from multiple sources, including original documentation, but also from satellite data. For case study 3, SarVision, a company which provides monitoring systems for natural resources management, carried out a pilot analysis of changes in land cover and vegetation characteristics. To gain a insight in how satellite data can be of assistance in a broader understanding of the context of a location. For example: What does the surrounding area look like and on which ecosystem services does it depend?

Step 2: Aligning the provided land cover data with land cover and biome/ecosystem definitions used in the ESVD

The goal of step 2 is to align the land cover information included in the case study description with the ESVD biomes and ecosystems. For the first two case studies, the alignment ('translation') was based on information that was provided on the land cover type while for the last two case studies, the translation was based on an investigation of the location of the project and/or the type of ecosystems in the vicinity. The translation into ESVD biomes and ecosystems is based on two criteria: (1) Most closely resembling the biome/ecosystem types used in ESVD and (2) the availability of monetary values in the ESVD. In the ESVD, the biome/ecosystem most closely resembling the land cover provided is generally used for the assessment. Depending on the availability of data for the best matched ecosystem, i.e. if there is a very limited number of monetary values for an ecosystem, closely related ecosystems can also be used. In these cases, the monetary values from the first ecosystem will be supplemented by monetary values from closely-related ecosystems. Oftentimes, there is a trade-off between biome/ecosystem availability and the number of available values. For example, for the Madagascar case on dryland forests, there was no data available in the ESVD. Therefore, after a discussion with experts, monetary values from tropical dry forests (global data) were used and this was supplemented with temperate rain & evergreen forest data (also on a global scale).

Step 3: Calculating the standardized monetary values of ecosystem services provided by the relevant biome/ecosystems for different land cover scenarios

The goal of step 3 is to extract monetary values of the different ecosystem services provided by the different biomes and ecosystems from the ESVD and then to calculate the monetary value of these services per biome/ecosystem. To calculate a summary value, we took the average values of the different standardized monetary values per ecosystem service for a biome/ecosystem. We removed outlier values (extreme high or low values) based on expert judgement from our own team of specialists. A value could be considered an outlier if it reflects a substantial part (approximately >50%) of the summary value. However, values, and therefore also outlier removal is very context-specific and there is no standard rule. For example, because of the high and unique biodiversity of dry forests in Madagascar, the value of the ecosystem service “maintenance of genetic diversity” is large and makes up over 50% of the total value, while not being considered an outlier.

In each case study, there were ecosystem services for which there was no ESVD data available, but which were likely to be provided by the selected biomes/ecosystems. These services were marked in blue/grey in the tables 1-5. This means that for all case studies, the total monetary value of ecosystem services provided is most likely an underestimate of the true value of the involved ecosystem because some services could not be accounted for.

Step 4: Calculating the Total Economic Value and the Net Present Value

The goal of step 4 is to calculate the changes in monetary value of the total bundle of ecosystem services provided by the case study area to illustrate the implications of an investment in terms of monetary gains and losses for private and public stakeholders. The outcomes of step 4 are discussed in detail in the results sections of the case studies (Chapter 3).

First, the **Total Economic Value (TEV)** is calculated. The TEV reflects the maximum potential sustainable use of the total bundle of ecosystem services provided by a particular ecosystem for a specific area, per year. Usually, TEV is expressed for a specific ecosystem in value/ha/year. To compare different land use scenarios, the TEV/ha/year is multiplied by the total area of that specific ecosystem. In case the study area consists of different ecosystems, the TEV values should be added to arrive at the TEV for the entire area. The TEV enables comparison of the monetary values of the chosen scenarios before and after land cover change, or other interventions. In our case, we defined two ’static’ situations (the current situation and the projected new situation) without taking the time-factor into account. In principle the TEV can be calculated more precise in a dynamic way, provided more information is available on the changes in ecosystem service provision over time.

Some important notes on the TEV in the context of this report:

The TEV-data included in the ESVD reflects the potential maximum sustainable use value of the total bundle of services provided by an ecosystem at a given point in time (currently ESVD data is standardized for 2020 in int$/ha). Transferring this information to a particular case study needs to be done with care. For example, in case study 3, timber is harvested, but recreation was not possible due to access restriction of the total area. However, since we are looking at the potential maximum sustainable use value, recreation services are taken into account as a potential ecosystem service.

Once we calculated the TEV, the **Net Present Value (NPV)** can be calculated. The NPV takes the time horizon of a project into account. It is calculated by using projections of the flows of the total bundle of ecosystem services from a given ecosystem (i.e., the TEV) over a given time period at a certain discount rate. The discount rate expresses the preference between the value of money today and in the future. A high discount rate means we place less value on future costs and benefits. The discount rates used for all case studies is 5%, which is a compromise between a lower discount rate that should be used for conservation and restoration projects which provide benefits in the longer term (usually between 0-5%, some even argue for a negative discount rate for restoration projects), and higher discount rates that are usually used for agricultural systems and other land uses aiming for short-term benefits (10% or more). When interpreting the results of our study, it is important to realize that by using the same discount rate for all scenarios, we thus implicitly over-estimate the NPV for agricultural systems and under-estimate the NPV for natural systems.

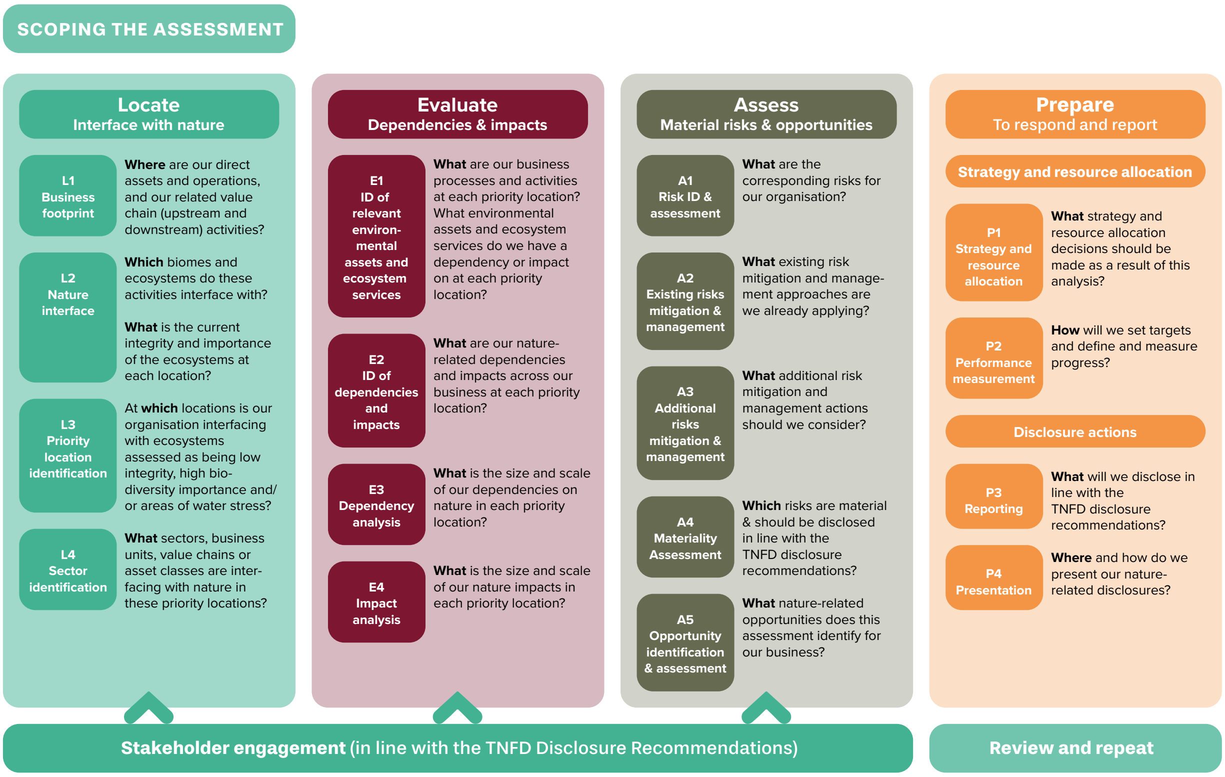
General methodological considerations

- We did not, and could not, take interactions between services, and changes over time into consideration, we only compared the current situation with a hypothetical future 'end point' assuming a constant TEV. For example: harvesting timber most likely impacts the condition of a forest to provide other services such as erosion prevention or filtration of air pollutants. Also, reforestation rates are not taken into account. For example, it takes multiple years, often decennia before a forest is mature and can provide all services. In this study we calculated the TEV for the potential 'end point', namely a fully functioning forest, not correcting for growth rates, and other changes during the project life time that influence the provisioning of ecosystem services.
- Disservices (i.e., ecosystem processes and dynamics which have a negative influence on human wellbeing), are not taken into account. Examples of disservices are occurrence of new pests in crops after land use change, a wetland which provides a nursery for mosquitoes and stinging flies or invasive species in South-African bushlands which are very fire prone, resulting in wildfires.
- Negative off-site externalities of land management resulting from investments practices are also not taken into account. These are very prevalent in human-dominated ecosystems such as agricultural lands. An example is fertilizer run-off from a corn field which influences ecosystems downstream, another example is a eucalyptus plantation which subtracts water resources from a surrounding wetland, river or forest area.
- For human-dominated biomes (cultivated areas), only provisioning ecosystem services have been taken into consideration. Of course, agricultural land also 'provides' other services (e.g., may have aesthetic qualities and some biodiversity benefits) but these are mostly negative, especially the regulating services (e.g., impact on water, air and soil quality).

2.2 USE OF THE ESVD IN LEAP; DETERMINING BIODIVERSITY RELATED RISK CATEGORIES

During the writing of this report the TNFD published their new LEAP framework. Because this framework is at the heart of the developments in nature related financial disclosure, we took this opportunity to demonstrate how the location-based integrated ES assessment-approach actually feeds into this framework. Therefore, in chapter 4, we explore how our assessment of the change in ecosystem services and its monetary value caused by the four cases can be used to better assess, respond to and report on the biodiversity related risks. We applied the risk management and disclosure framework LEAP (Locate, Evaluate, Assess, Prepare) of the TNFD (see Figure 2). The TNFD provides a knowledge bank that includes links to various information sources and tools that can be used to fill in the LEAP framework. However, no guidance is given on what to potentially use in each of the 17 analytical components of the LEAP methodology. For each of the components we determine whether and how the information from the ESVD and satellite information can be applied. We especially focus on the components within the blocks 'Locate', 'Evaluate' and 'Assess'. We illustrate how information on ecosystem services and its monetary value can be used as indicators to determine the different biodiversity related risk categories.

Figure 2: The first version of an integrated nature-related risk and opportunity assessment process developed by TNFD, called LEAP: Locate, Evaluate, Assess, Prepare. These four core phases are broken down into 17 analytic components for corporates, each framed by a guiding question (TNFD, 2022)



3 Case studies

This chapter describes the assessment of the changes in the monetary value of ecosystems services and the subsequent changes in societal benefits and losses for the four case studies, based on the data obtained from the ESVD.

3.1 CASE STUDY 1: REFORESTATION IN THE GEELDERS, THE NETHERLANDS

3.1.1 Context

Two environmental organizations have obtained an investment to reforest at least 40 ha on agricultural fields near “the Geelders”, a forest reserve near the city of Boxtel in the province of North-Brabant in the Netherlands. In this case study, we compare the change in the provision of ecosystem services and its monetary value between the baseline scenario which is the continuation of the current agricultural practices with a reforestation scenario. The project has the ambition to connect the reforested areas to existing surrounding nature reserves such as the ‘Dommeldal’. Between 2020 and 2024, the organizations will plant trees to restore a specific ecosystem, loam forests (leembossen). This is a native forest ecosystem on a loam substrate, which is a soil layer about two meters deep in the soil through which water cannot move. As a result, trees will stand in the water for several months during fall and winter. The objective of the reforestation is to create self-sustaining robust nature reserves with a high biodiversity. Furthermore, reforestation will restore the ground water levels which feeds into another ambition of this project: to strengthen the surrounding nature reserves.

The forest type to be restored is loam forests. For this specific ecosystem, no valuation data is available in the ESVD. Therefore, we agreed to use valuation data of temperate deciduous forests, as most closely resembling loam forests (see appendix 1 for more information).

3.1.2 The effect of investments on the value of ecosystem services

Table 1 provides an overview of the ecosystem services and its monetary value in both scenarios.

Table 1: TEV of current agricultural use in the Geelders compared to turning the area into forest. Total area 40ha, values in $2020/year.

Services	Scenario 1: Current agriculture	Scenario 2: Future forests	Difference
Provisioning services	**93.2 K**	**1.6 K**	**-91.6 K**
Food	$0	0.03 K	0.0 K
Water	$0	$0	$0
Raw materials	93.2 K	1.5 K	-91.6 K
Genetic resources	$0	$0	$0
Medicinal resources	$0	$0	$0
Ornamental resources	$0	$0	$0
Regulating services	**$0**	**87.6 K**	**87.6 K**
Air quality regulation	$0	63.2 K	63.2 K
Climate regulation	$0	12.2 K	12.2 K
Moderation of extreme events	$0	0.2 K	0.2 K
Regulation of water flows	$0	4.8 K	4.8 K
Waste treatment	$0	$0	$0
Erosion prevention	$0	7.1 K	7.1 K
Maintenance of soil fertility	$0	$0	$0
Pollination	$0	$0	$0
Biological control	$0	$0	$0
Habitat services	**$0**	**99.7 K**	**99.7 K**
Maintenance of life cycles	$0	$0	$0
Maintenance of genetic diversity	$0	$0	$0
Existence. bequest values	$0	99.7 K	99.7 K
Cultural services	**0.1 K**	**22.8 K**	**22.7 K**
Aesthetic information	0.01 K	$0	-0.01 K
Opportunities for recreation and tourism	$0	14.8 K	14.8 K
Inspiration for culture. art and design	0.1 K	$0	-0.1 K
Spiritual experience	$0	$0	$0
Information for cognitive development	$0	8.0 K	8.0 K
Total	**93.3 K**	**211.7 K**	**118.4 K**

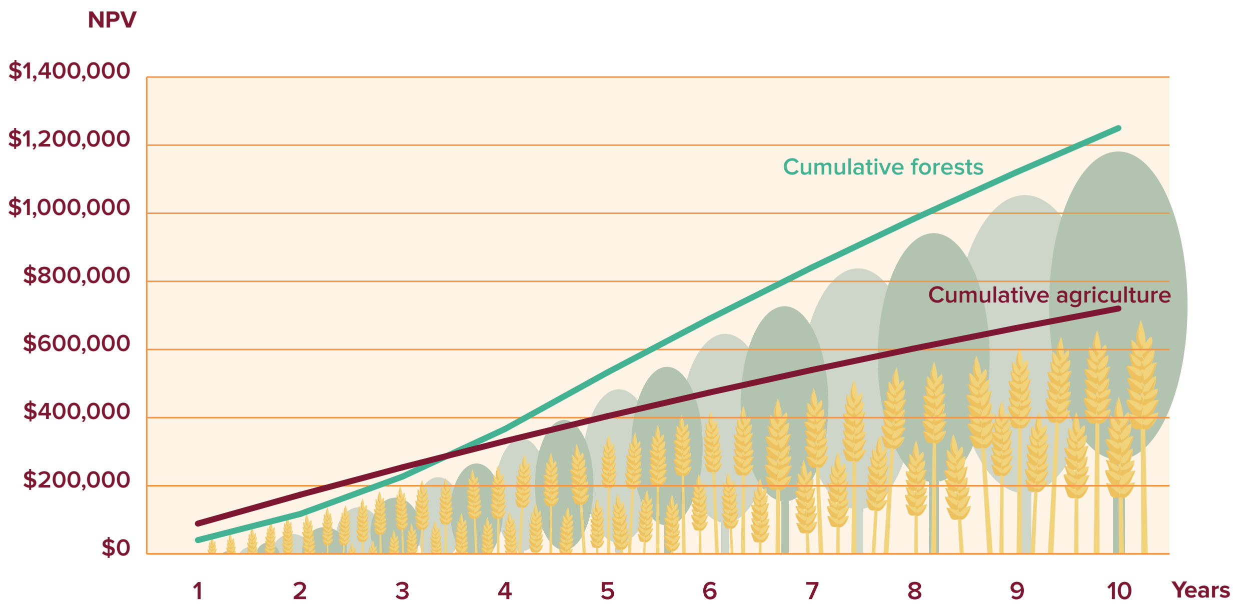
The grey color signifies the services which are provided by the ecosystem, but for which no data exists in the ESVD. The cells in the last column with a green background show the increase in the monetary value of ecosystem services after the land cover change from agriculture to forests and the cells with a red color, the services which are negatively influenced by the land cover change.

The land cover change from agriculture to forests results in a net-positive impact as the projected forest TEV is almost three times as large as the current agricultural TEV. This is mainly the result of the much higher value of regulating services like air quality regulation, climate buffering, groundwater replenishment, habitat protection and recreational benefits.

The large difference in economic value of the two scenarios is also visible when calculating the NPV (see Figure 3 and Figure 4). Over a time span of 10 years at 5% discount rate the NPV of agriculture is approximately $0.7 million ($17,500/ha) while the forest scenario shows a NPV of approximately $1.2 million (approx. $31,000/ha) over a time-span of 10 years. Although the reforestation takes 5 years to complete (based on 8 hectares of reforestation per year), the forest NPV already exceeds the agricultural NPV after three years and continues to grow. Because reforestation takes many years to succeed, the full range of benefits will only accrue after several years (see the discussion for more detail).

This indicates the importance of taking a longer time horizon over a short-term horizon for investments in restoration.

Figure 3: NPV of current agricultural use in the Geelders compared to turning the area into forest. Total area 40ha, values in $2020.

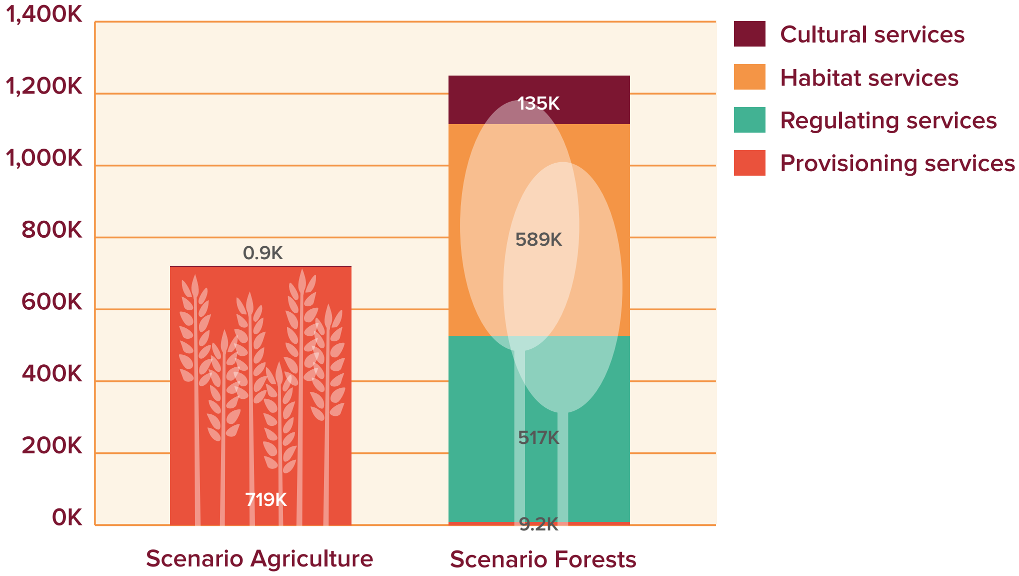


The Net Present Value of the project for up to a time-span of 10 years with a 5% discount rate. The NPV in year one reflects the present value of the investment in year 1. The NPV of year 10 includes the cumulative value for a period of 10 years.

Table 1 and Figure 4 show that the ecosystem services in the agriculture scenario almost solely consist of provisioning services with a NPV of $720,000. This value will be 'lost' after reforestation but the by many regulating, habitat and cultural services which are restored and together represent a substantially larger monetary value than the total economic value in the agricultural scenario (see figure 4). The actual values are probably even higher than presented since some ecosystem services could not be assessed because of missing data (cells in Table 1 with blue/grey background). Contrary to the agricultural scenario, in the forest scenario a large variety of stakeholders benefit from the ecosystem services. Local and global communities (public entities) and nearby farmers profit from regulating services such as regulation of water flows, carbon sequestration and air quality regulation. Tourists and businesses active in the recreational sector profit from increased recreational possibilities due to the restored biodiversity and increased habitat.

This shows that the reforestation project reduces food production and private benefits flowing from food production, but it increases biodiversity and many other 'public' ecosystem services which increases the overall total 'social value' for society.

Figure 4: NPV of current agricultural use in the Geelders compared to turning the area into forest. Total area 40ha, values in $2020, separated by ecosystem services category.



3.1.3 Conclusion

This integrated ecosystem services assessment shows the 'true' values of an ecosystem, beyond the limited market values. Most regulating, habitat and cultural services, which increase after reforestation in the Geelders, are vital to societies, but cannot be traded in markets. This case study makes these 'hidden' benefits visible and therefore sheds a new light on the importance of ecosystems. The change in land cover can thus be translated into changes in benefits, for private as well as for public stakeholders.

The distribution of benefits and losses from a changing flow of ecosystem services can be related to the type of stakeholder bearing these benefits and/or losses. This reforestation project highlights that most likely societal stakeholders benefit through the removal of air pollutants and carbon, through higher moderation of extreme events, existence values, improved recreational possibilities and through increased opportunities for cognitive development. The final two benefits might also favor the tourist and the scientific industry. Farmers are most likely to lose some benefits due to a lower flow of provisioning services, however, surrounding farmers might benefit from a higher erosion control, higher moderation of extreme events and if relevant, from pollinating services.

The possible implications for stakeholders and the insight that many non-market services are provided, pin-points towards the direction of responsibility and incentivizes the development of blended finance mechanisms to sustainable investments, for investors, the public and nature.

3.2 CASE STUDY 2: REFORESTATION IN MADAGASCAR

3.2.1 Context

In Western Madagascar, only 3% of the original lowland dry forest still exists today. Therefore, it is one of the most threatened ecosystems in the world (Trees for all, 2020). The goal of the reforestation project in Madagascar is to convert 150 hectares of degraded pastures or shrubland into dryland forest (bare and shrubland) over the next three years (50 ha per year). The project will be an extension of the current reforestation area of Zazamalala. It is situated in Toliara and Morondava in the region of Menabe, West Madagascar. The overarching and long-term mission is to enhance the existing forest with a 30 km green corridor through eroded land towards the north, combining Zazamalala with the nearby situated Mena Be Nature Reserve. In this case study we compare the baseline scenario of the degraded shrubland with the planned dry forest scenario.

The restored forest will be protected for at least 10 years, with a commitment from partner organizations to protect the forest for 30 years. The plan consists of planting endemic plants and tree species next to two exotic tree species. The idea of planting the exotic species is that they quickly cover the area with their canopy and out-shade the grasses. In addition, the exotic tree species are nitrogen fixing species that increase the soil fertility. Moreover, both species give the planting area the impression of a forest after only a few years and attract animals and bird species (Trees for all, 2020). The exotic tree species will be cut down from year 10 onwards and their place will be 'conquered' by the surrounding indigenous trees and climax species as the critically endangered Hazomalany ( ) that solely grows in shade during its seedling stage.

The dry forest ecosystem in Madagascar is a very specific ecosystem for which (ESVD) valuation data is scarce. As a consequence, a combination of the most resembling ecosystems for which ESVD data exists, were used, namely tropical dry forests supplemented with evergreen forest data (see also chapter 2.2). For degraded shrubland, ESVD data on the degraded Woodland & Shrubland biome was chosen.

3.2.2 The effects of investments on the value of ecosystem services

Table 2 provides an overview of the ecosystem services and their monetary value in both scenarios.

Table 2: TEV of current degraded shrublands in the Zazamalala compared to turning the area into forest. Total area 150ha, values in $2020/year.

Ecosystem services	Scenario 1: Current shrublands	Scenario 2: Future forests	Difference
Provisioning services	**6.9 K**	**0.1 M**	**0.1 M**
Food	6.9 K	$0	-6.9 K
Water	$0	28.9 K	28.9 K
Raw materials	0.01 K	53.1 K	53.1 K
Genetic resources	$0	$0	$0
Medicinal resources	0.001 K	58.8 K	58.8 K
Ornamental resources	$0	$0	$0
Regulating services	**10.1 K**	**0.4 M**	**0.3 M**
Air quality regulation	$0	0.3 M	0.3 M
Climate regulation	10.0 K	30.6 K	20.6 K
Moderation of extreme events	$0	$0	$0
Regulation of water flows	$0	$0	$0
Waste treatment	$0	$0	$0
Erosion prevention	$0	24.3 K	24.3 K
Maintenance of soil fertility	$0	5.9 K	5.9 K
Pollination	$0	$0	$0
Biological control	0.04 K	$0	0.0 K
Habitat services	**1.0 K**	**1.4 M**	**1.4 M**
Maintenance of life cycles	$0	$0	$0
Maintenance of genetic diversity	$0	1.4 M	1.4 M
Existence. bequest values	1 K	$0	-1.0 K
Cultural services	**0.001 K**	**0.6 M**	**0.6 M**
Aesthetic information	$0	$0	$0
Opportunities for recreation and tourism	0.001 K	0.9 K	0.9 K
Inspiration for culture. art and design	$0	$0	$0
Spiritual experience	$0	$0	$0
Information for cognitive development	$0	0.6 M	0.6 M
Total	**18.0 K**	**2.5 M**	**2.5 M**

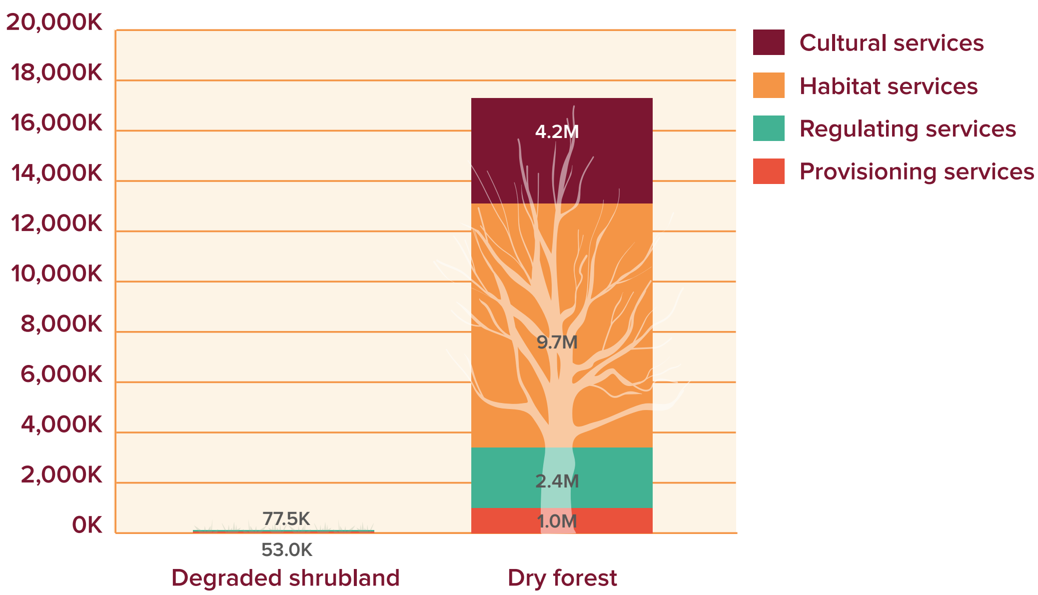
The cells in the last column with a green background show the increase in the monetary value of ecosystem services after the land cover change from agriculture to forests and the cells with a red colour, the services which are negatively influenced by the land cover change. The cells in blue/grey show the services for which no ESVD data exists, but which are likely to be provided.

The TEV of the dry forest is with $2.5 million/year (150 ha) significantly larger than the $18,000/year (150ha) of the degraded shrubland (Table 2). Since the project area currently consists of severely degraded pastures and shrubland, it provides only few ecosystem services while the restored dry forest will be able to provide many different services which will also benefit a large diversity of stakeholders in the project area and beyond.

Over half of the dry forest TEV stems from maintenance of genetic diversity ($1.4 million/year for the entire area of 150 ha, or over $9,000/ha/year). This is an important value as the dry forest of Madagascar, and Madagascar in general, is a biodiversity hotspot with very high levels of endemism and special species such as the Baobab tree (Trees for all, 2020 & CBD, n.d., & One Earth, n.d.). The monetary values of air quality regulation and information for cognitive development in the dry forest also appear to be high. This stems from the uptake of air pollutants such as fine dust by trees and from the scientific and educational value of the biodiverse area.

It is anticipated that local communities will benefit from the forest restoration by having better access to water and medicinal resources. One of the aims of the project is to decrease the use of wood for cooking by delivering solar cooking. However, for the purpose of this assessment, raw materials (incl. firewood) were still included. Local communities and farmers, as well as some businesses will benefit in the longer term from improved erosion control and climate regulation provided by the restored forest. Finally, increased opportunities from recreation and tourism will benefit local businesses and communities. Since grazing and farming will be prohibited, they will be negatively affected by the land cover change, but may be compensated by finding other employment.

Figure 5: the NPV of degraded shrubland compared to dry forest restoration given a project time-span of 10 years and a 5% discount rate for the four main ecosystem services categories



According to our desk-study, the degraded shrubland scenario has a NPV of approximately $0.13 million (approx. $870/ha), if we consider a time-span of 10 years, while the dry forests scenario has a total NPV of $17 million ($115,000/ha) (figure 5). Because the forest will be planted during the first 3 years, the NPV increases with the increasing area of reforestation (not shown).

3.2.3 Conclusion

The only service that decreases in value is food provision (farming), while all other services will increase. Even if we exclude the large value we found for habitat protection, the TEV and NPV reflect that it is very beneficial to convert the project area into a forest, especially from a public benefits perspective, similar as in the case study of the Geelders with increased opportunities for tourism, filtering of air pollutants, the uptake of carbon, increased maintenance of soil fertility and increased habitat benefitting local communities. Local businesses might positively benefit from increased tourism as well, and local famers might benefit from soil fertility, erosion prevention and from a likely increase in pollination and regulation of water flows.

It is important to consider a long-time horizon because it generally takes more than 15 years for a reforestation project to be realized and for the flow of ecosystem services to manifest fully.

This case study also helps to identify the diversity of stakeholders that are potentially influenced as well as the distribution of ecosystem services over these stakeholder groups, thereby providing better insight in the risks and opportunities of investors.

3.3 CASE STUDY 3: EUCALYPTUS PLANTATIONS IN PARAGUAY

3.3.1 Context

A Paraguayan company created in 2019 has bought a concession of land in Paraguay. The location of the concession is north-west of Ascension (the exact location is known to the team). Before the concession was bought, the area consisted of agricultural and cattle land, and some wetland, Cerrado and forest ecosystems. The aim of the investment is to convert most of the agricultural land into eucalyptus plantations. Of the total forested area, 25% (i.e., 464 ha) needs to maintain its original natural forest cover.

There are many different ecosystems to be considered in this case study. For our study we compared the changes within the natural and human-dominated ecosystems before and after the land cover change (see Table 3 below). For example, the values of forest before the investment are compared to the value of forests after the investment.

Table 3: The distribution of ecosystems in the current situation with mainly agriculture versus the future situations, with mainly eucalyptus.

Biomes/scenarios	Current situation (2686 ha)	Alternative scenario (2695 ha)
Forest	501	527
Eucalyptus	0	1841
Wetland	313	267
Cerrado	55	55
Pastures	532	0
Agriculture	1285	6

The company considers eucalyptus plantations as reforestation and aims to seek FSC certification. In addition, they state that the are currently consists of some heavily degraded Atlantic and temperate evergreen forests which are characterized by very few trees of commercial value. The goal is to also conserve and regenerate the degraded forests. However, it is not yet clear from the documentation where and how the company will do so. In this case, we compare the baseline scenario (no change in current land cover types) with the eucalyptus scenario.

3.3.2 The effects of investments on the value ecosystem services

Table 3 shows the TEV of the current land use and the future situation. There is some extra forest and a reduction in the size of the wetlands as a result of the investment (see table above). However, the natural ecosystems (forests, wetlands and Cerrado) see minor changes in land cover as a result of the investment and therefore differences in flow of ecosystem services between the before and after scenarios are also small. The differences between the ecosystems where human intervention takes place from agriculture and pastures before and plantations after, are large. The TEV of these cultivated areas increases from $1.1 million (2686 ha/yr) in the baseline scenario to $3 million (2695 ha/year) in the eucalyptus scenario, this difference is only caused by the large value of raw materials for eucalyptus trees. However, a eucalyptus plantation has a rotation time of 13 years, meaning that eucalyptus can only be harvested in year 13 after it has been planted. Therefore, to come to a TEV value for the eucalyptus plantation, the economic value at year 13 (approx. $38 million) has been divided by 13 to obtain the TEV.

Table 4: TEV of the two different scenarios in the concession area (in $2020). Forests before (501 ha), forests after (526.5 ha), wetlands before (313 ha), wetlands after (267 ha), Cerrado before and after (55 ha), agriculture before (1285 ha), pastures before (532 ha), Eucalyptus after (1841 ha) and agriculture after (6 ha). The grey colour shows the services which are provided by the ecosystem, but for which no data exists in the ESVD.

Services/scenarios	Scen.1: Current forests	Scen.2: Future forests	Scen.1: Current wet-lands	Scen.2: Future wet-lands	Scen.1: Current cerrado	Scen.2: Future cerrado	Scen.1: Current pastures	Scen.1: Current agri-culture	Scen.2: Future Euca-lyptus	Scen.2: Future agri-culture
Provisioning services	**0.3 M**	**0.4 M**	**0.1 M**	**0.1 M**	**25.7 K**	**25.7 K**	**0.2 M**	**1.1 M**	**3.0 M**	**5.2 K**
Food	11.2 K	11.8 K	18.7 K	15.9 K	4.9 K	4.9 K	0.2 M	1 M	$0	5.2 K
Water	0.2 M	0.2 M	26.2 K	22.3 K	17.4 K	17.4 K	$0	$0	$0	$0
Raw materials	0.1 M	0.1 M	88.0 K	75.0 K	3.4 K	3.4 K	$0	$0	3.0 M	$0
Genetic resources	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Medicinal resources	2.0 K	2.1 K	$0	$0	0.01 K	0.01 K	$0	$0	1.3 K	$0
Ornamental resources	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Regulating services	**1.2 M**	**1.3 M**	**2.3 M**	**1.9 M**	**5.6 K**	**5.6 K**	**17.3 K**	**$0**	**$0**	**$0**
Air quality regulation	1.0 M	1.0 M	$0	$0	$0	$0	$0	$0	$0	$0
Climate regulation	0.2 M	0.2 M	1.5 M	1.3 M	5.4 K	5.4 K	13.7 K	$0	$0	$0
Moderation of extreme events	$0	$0	0.2 K	0.1 K	$0	$0	3.6 K	$0	$0	$0
Regulation of water flows	$0	$0	2.3 K	2.0 K	0.1 K	0.1 K	$0	$0	$0	$0
Waste treatment	5.1 K	5.3 K	0.8 M	0.6 M	$0	$0	$0	$0	$0	$0
Erosion prevention	27.5 K	28.9 K	$0	$0	$0	$0	$0	$0	$0	$0
Maintenance of soil fertility	19.7 K	20.7 K	$0	$0	$0	$0	$0	$0	$0	$0
Pollination	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Biological control	$0	$0	$0	$0	0.02 K	0.02 K	$0	$0	$0	$0
Habitat services	**0.2 M**	**0.2 M**	**1.9 K**	**1.6 K**	**0.8 K**	**0.8 K**	**$0**	**$0**	**$0**	**$0**
Maintenance of life cycles	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Maintenance of genetic diversity	0.2 M	0.2 M	1.9 K	1.6 K	0.1 K	0.1 K	$0	$0	$0	$0
Existence. bequest values	23.1 K	24.3 K	$0	$0	0.8 K	0.8 K	$0	$0	$0	$0
Cultural services	**1.6 M**	**1.6 M**	**29.2 K**	**24.9 K**	**10.4 K**	**10.4 K**	**0.2 M**	**$0**	**$0**	**$0**
Aesthetic information	$0	$0	27.4 K	23.4 K	$0	$0	0.2 M	$0	$0	$0
Opportunities for recreation and tourism	$0	$0	1.8 K	1.6 K	10.4 K	10.4 K	$0	$0	$0	$0
Inspiration for culture. art and design	3.0 K	3.1 K	$0	$0	$0	$0	8.1 K	$0	$0	$0
Spiritual experience	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Information for cognitive development	1.6 M	1.6 M	$0	$0	$0	$0	$0	$0	$0	$0
Total	**3.3 M**	**3.5 M**	**2.4 M**	**2.1 M**	**42.5 K**	**42.5 K**	**0.5 M**	**1.1 M**	**3.0 M**	**5.2 K**

Table 4 highlights the TEV for both scenarios. Regulating, habitat and cultural services are very prevalent for the in the natural ecosystems, while the largest monetary value for human-dominated ecosystems come from provisioning services. In the current scenario, forests ($3.3 million) have a larger value compared to the forest as a result of the investment ($3.5 million). The most improtant forest ecosystem services are maintenance for cognitive development, air quality regulation, the provisioning of water and mainenance of genetic diversity. The TEV of wetlands decreases slightly from $2.4 million to $2.1 million because of a decrease in area, the most important services being climate regulation, waste treatment and the provisioning of raw materials. The TEV for human-dominated systems increases to $3 million, from approximately $1.6 million, stemming from an increase of raw materials in the form of harvesting timber from the eucalyptus plantation. Important to note, climate regulation as a service for the eucalyptus plantation has not been taken into account as there are critiques on the investment, one point being the likeliness of the end-use of the eucalyptus to be used as firewood for drying agricultural goods such as soy beans (Global Forest Coalition, n.d.). When using eucalyptus as firewood, the carbon sequestrated gets emitted. Therefore, we chose to not account for climate regulation.

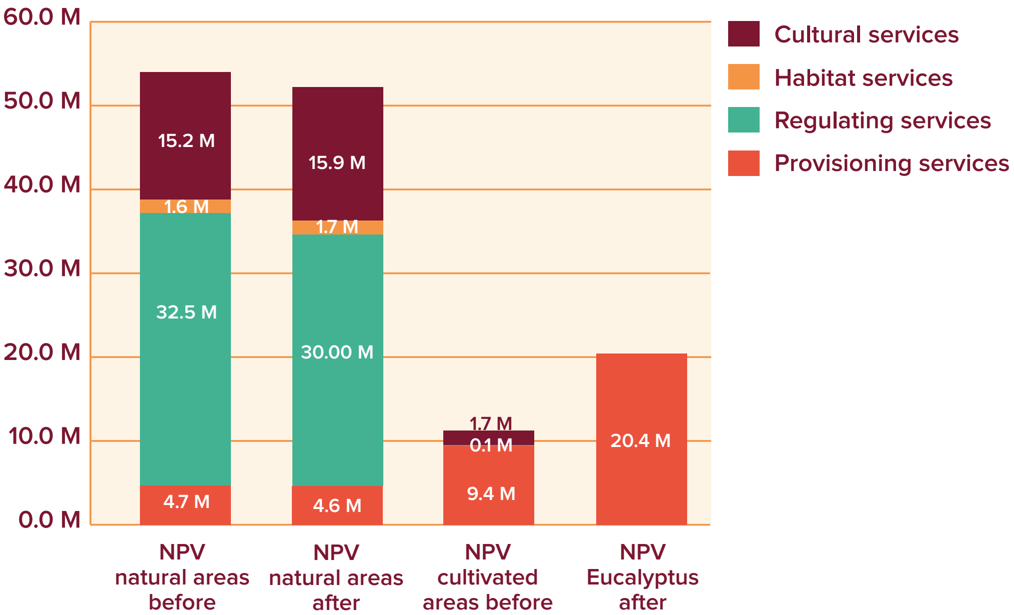
Table 5: The differences in TEV before and after the land cover change. The positive (green) outcome reflects that the land cover change has increased the number of services while the negative (red) outcome highlights those services have been lost as a result of the land cover change.

Ecosystem services	Differences between scenarios forests	Differences between wetland scenarios	Differences between scenarios Cerrado	Differences between scenarios agriculture
Provisioning services	**0.02 M**	**-0.02 M**	**$0**	**1.6 M**
Food	0.6 K	-2.7 K	$0	-1.32 M
Water	0.01 M	-3.8 K	$0	$0
Raw materials	0.01 M	-0.01 M	$0	3.0 M
Genetic resources	$0	$0	$0	$0
Medicinal resources	0.10 K	$0	$0	1.3 K
Ornamental resources	$0	$0	$0	$0
Regulating services	**0.06 M**	**-0.3 M**	**$0**	**-0.02 M**
Air quality regulation	0.05 M	$0	$0	$0
Climate regulation	0.01 M	-0.2 M	$0	-0.01 M
Moderation of extreme events	$0	-0.02 K	$0	-3.6 K
Regulation of water flows	$0	-0.3 K	$0	$0
Waste treatment	0.3 K	-111 K	$0	$0
Erosion prevention	1.4 K	$0	$0	$0
Maintenance of soil fertility	1.0 K	$0	$0	$0
Pollination	$0	$0	$0	$0
Biological control	$0	$0	$0	$0
Habitat services	**0.01 M**	**-0.28 K**	**$0**	**$0**
Maintenance of life cycles	$0	$0	$0	$0
Maintenance of genetic diversity	0.01 M	-0.3 K	$0	$0
Existence. bequest values	1.2 K	$0	$0	$0
Cultural services	**0.08 M**	**-4 K**	**$0**	**-0.2 M**
Aesthetic information	$0	-4 K	$0	-0.2 M
Opportunities for recreation and tourism	$0	-0.3 K	$0	$0
Inspiration for culture. art and design	0.2 K	$0	$0	-0.01 M
Spiritual experience	$0	$0	$0	$0
Information for cognitive development	0.08 M	$0	$0	$0
Total	0.2 M	-0.4 M	$0	1.4 M

As Table 5 shows, the TEV of the forest area increases with $200,000/year (based on a 25ha increase) while the TEV of the wetlands decreases by $400,000/year (46 ha increase). The changes in the natural area are solely stemming from a change in area. The value of the agricultural area increases by $1.4 million/year (for 30ha increase). This change, however, is mainly caused by the change from soybean, corn (agriculture) and pastures to eucalyptus, having a higher market value.

Figure 6 shows the difference of the NPV between the natural ecosystems (forests, wetlands and Cerrado) and cultivated ecosystems (pasture and agriculture) if a time-span of 13 years is considered. The NPV clearly shows that there is only an increase in provisioning services as a result of the high market value for eucalyptus plantations. This increase in value benefits the company owning the premise. The eucalyptus plantation provides only few other ecosystem services therefore mainly stakeholders in the agricultural sector will benefit from the investment. Other stakeholders such as surrounding farmers and communities might even experience a small loss in ecosystem services due to the disappearance of some wetland area. Ecosystem services which decrease are water retention, moderation of extreme events and the filtering of pollutants (waste). This can potentially trigger a negative impact on various risk categories. Another interesting observation arising from this analysis is that the total societal benefits of the (smaller area of) natural areas (forests, Cerrado and wetland ecosystems) are larger than the total private benefits stemming from ecosystem services provided by the agricultural ecosystem (Table 5 and figure 6). Which demonstrates that natural areas deliver more ecosystem services and raise a higher value in their worth to society then agricultural ecosystems do.

Figure 6: The NPV of the private and public benefits on the concession area over 13 years with a 5% discount rate in$2020, separated by natural and cultivated area.



3.3.3 Conclusion

The outcome of this case study (visualized in Figure 6) warns to be cautious with the positive impacts that investments initially seem to have when we only include market values (the red part of the bars in Fig 6), as is usually done. Our analysis indicates that, although the project is presented as reforestation and landscape restoration and even certification is applied, it does not seem to guarantee maintenance of the total flow of ecosystem services in other parts of the location. It shows the importance of taking all ES categories into account when analyzing this kind of large-scale land cover changes. Often the diverse mix of positive and negative impacts is not perse reflected in certification and this integrated ES assessment approach can help to make certification more inclusive.

The case study is therefore a strong example of what we see when we look beyond the metrics of biodiversity protection and carbon credits. It adds the 'true' values of an ecosystem to the equation. As mentioned before, most regulating, habitat and cultural services are vital to societies, but, unlike most provisioning services, cannot be traded in markets.

This case study shows a loss of cultural and regulating services (measured in shadow prices) and a benefit of provisioning services (measured in market prices). By making use of the TEV generated from the ESVD, we can relate these changes in benefits coming from ecosystem services to the various stakeholders, local communities, society at large and businesses. This pinpoints the direction of which risks are at stake. For example, the lower ability of wetlands to provide the regulating service of waste treatment. This loss might influence a physical risk in the form of a dependency because of the smaller capacity of an ecosystem to filter harmful pollutants in the area which might influence operations.

There are also reputational risks which stem from a general decrease of all service categories, and specifically pollution, which influences other societal stakeholders.

The understanding of this correlation incentivizes the development of multi-stakeholder approaches in investments and blended finance mechanisms.

3.4 CASE STUDY 4: SHADED COFFEE IN NICARAGUA

3.4.1 Context

A Nicaraguan coffee production company has a shaded coffee system of 138 hectares. In addition, the company owns 52 hectares of native cloud forests. The location of the shaded coffee system is near the city of Matagalpa, the fourth largest city of Nicaragua (the approximate location is known by us). This final case study is not about an existing land cover change, but on a hypothetical land cover change from a conventional coffee system to a shaded coffee system.

3.4.2 The effects of investments on the value of ecosystem services

The TEV of the shade-grown system (agro-coffee (138 ha) + tropical rainforest (52 ha) is with $1.1 million/year ($0.9 million + $0.2 million) somewhat larger than the conventional coffee system: $ 900,000/year (190 ha) (Table 6). The value of the conventional coffee system is almost entirely based on the (market) value of the coffee (approx. $4,700/ha/y). This value is lower for the agro-coffee system: approx. $3,200 /ha/y (including the forest area). However, the shade-grown system provides additional services, such as climate regulation, pollination and biological control services leading to a TEV of approx. $5,800/ha/y. In reality, it is likely that the TEV of the agroforestry system is higher than shown here because many services could not be quantified (see the grey categories). No mention is made in the project proposal of production crops other than coffee, such as food crops and/or timber, which are usually provided in shade-grown coffee systems (Pinoargote et al, 2017). In addition, there is no information in the ESVD on four ecosystem services likely to be provided by tropical forest.

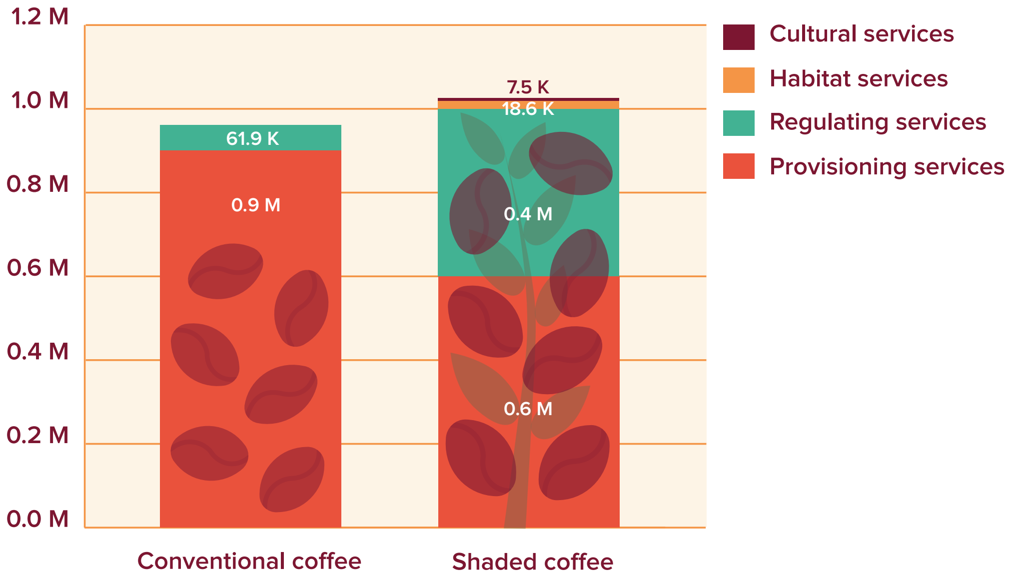
Table 6: TEV of two systems in int$/ha/yr. TEV of shade-grown system (column 4, 138 ha) and the tropical rainforest (column 3, 52 ha), together 190 ha form scenario 2: future situation. The TEV of the scenario 1: Current situation (conventional coffee) is ha 190. The grey color shows the services which are provided by the ecosystem, but for which no data exists in the ESVD. The green cells show the positive and the red cells the negative difference if a conventional coffee plantation was converted to a shaded coffee system with rainforests.

Services	Scenario 1: Conventional coffee	Scenario 2: Tropical rainforest	Scenario 2: Agro-coffee	Difference
Provisioning services	**0.9 M**	**90.2 K**	**0.6 M**	**-0.2 M**
Food	0.9 M	9.1 K	0.6 M	-0.2 M
Water	$0	20.3 K	$0	20.3 K
Raw materials	$0	34.1 K	$0	34.1 K
Genetic resources	$0	26.4 K	$0	26.4 K
Medicinal resources	$0	0.2 K	$0	0.2 K
Ornamental resources	$0	$0	$0	$0
Regulating services	**61.9 K**	**73.1 K**	**0.3 M**	**0.3 M**
Air quality regulation	$0	$0	$0	$0
Climate regulation	0.1 M	36.7 K	0.2 M	0.2 M
Moderation of extreme events	$0	1.3 K	$0	1.3 K
Regulation of water flows	$0	0.7 K	$0	0.7 K
Waste treatment	$0	0.5 K	$0	0.5 K
Erosion prevention	$0	23.8 K	$0	23.8 K
Maintenance of soil fertility	$0	$0	$0	$0
Pollination	$0	10.0 K	7.7 K	17.8 K
Biological control	$0	$0	59.8 K	59.8 K
Habitat services	**$0**	**18.6 K**	**$0**	**18.6 K**
Maintenance of life cycles	$0	$0	$0	$0
Maintenance of genetic diversity	$0	17.9 K	$0	17.9 K
Existence. bequest values	$0	0.7 K	$0	0.7 K
Cultural services	**$0**	**7.5 K**	**$0**	**7.5 K**
Aesthetic information	$0	$0	$0	$0
Opportunities for recreation and tourism	$0	1.9 K	$0	1.9 K
Inspiration for culture. art and design	$0	5.7 K	$0	5.7 K
Spiritual experience	$0	$0	$0	$0
Information for cognitive development	$0	$0	$0	$0
Total	**0.9 M**	**0.2 M**	**0.9 M**	**0.2 M**

Figure 7 shows that although the conventional coffee systems have a higher market value than shade-grown coffee (the red part of the bar) the overall TEV of the shade-grown coffee in combination with rainforest protections is higher.

Thus, investing in shade-grown coffee is beneficial from a societal point of view because it provides more regulating, habitat and cultural services, even though not for all services monetary values were found in the ESVD. These services benefit a wider group of stakeholders. Erosion prevention and moderation of extreme events are beneficial for the coffee company as well as for local communities, recreational services will benefit local entrepreneurs while climate regulation benefits society at large.

Figure 7: The TEV of the private and public benefits on concession area in int$2020/ha/yr. Private benefits constitute only provisional services while public benefits consist of regulating, habitat and cultural services.



3.4.3 Conclusion

The outcome that a shaded coffee system provides a broader distribution of ecosystem services underpins once again the importance of looking beyond provisioning services that can be traded at markets. Most regulating, habitat and cultural services are vital to societies, as well as to private stakeholders because they provide the services that are needed for truly sustainable land-use.

The ESVD makes these services visible by translating them in monetary terms. This allows ecosystem services a place on the balance sheet in cost-benefit analyses. In this way we take nature into account and bring the actual (long-term) risks and opportunities to the surface.

In this case, we see that the total bundle of ecosystem services provided in scenario 2 exceeds the value of the total bundle of scenario 1. So, by adding the 'externalities', the non-market but very real ecosystem services, we note that shade-grown coffee systems are preferred over conventional coffee systems.

This more complete perspective can be used to better understand existing trade-offs. When, in decision-making processes, provisioning services are valued while regulating, habitat and cultural services are not, stakeholders expose themselves to risks. For example, there are physical risks stemming from the decrease of regulating services such as climate regulation, erosion prevention and pollination. These risks could be a pre-cursor for reputational or even systemic risks.

On the other hand, when including the value of regulating, habitat and cultural services in the cost-benefit analysis, investors open themselves up to opportunities such as blended finance mechanisms (when you understand the flow of costs and benefits you have leverage to attract, for example, additional funding from other stakeholders) and mitigation measures.

4 The ESVD and LEAP; Determining biodiversity related risk categories

The fourth objective of this study was to gain an understanding of the fit of the ESVD and the application of monetary valuation with biodiversity-related risk assessments of financial institutions. In the next sections, we explain and demonstrate how the information from the ESVD, in combination with satellite data, can be applied to various components identified in the four groups of the LEAP methodology. We will show that the ESVD fits closely with the LEAP methodology and that monetary valuation of ecosystem services has the potential to be used in biodiversity-related risk assessments. The integration of the ESVD fits well with the first three steps (Locate, Evaluate and Assess), which form the basis for step 4 (Prepare), reporting and disclosing on nature-related risks and opportunities.

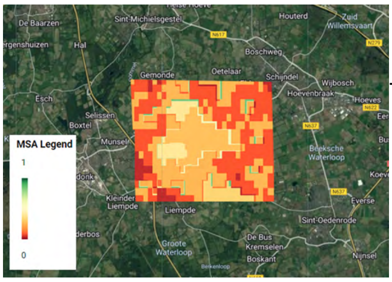
4.1 LOCATE – WHERE ARE OPERATIONS, ASSETS AND RELATED VALUE CHAINS LOCATED?

The first step of the LEAP methodology is ‘Locate – determine the interface with nature’ (which consists of a group of components; L1 – L4). The first component, L1 Business footprint, discusses the key question of this group: Where are operations and assets and the related value chain taking place? The four cases clearly demonstrated that a proper assessment of a change in ecosystem services and its monetary value can only be carried out if location information is available. Location information allows the identification of the ecosystems/biomes that are relevant (L2, Nature interface), the services they provide as well as the stakeholders that potentially benefit from these services. Ideally a full life cycle assessment of the products involved (if any) is made, including different locations of impact.

Components L2-Nature interface and L3 -Prioritisation according to the integrity and importance of relevant ecosystems of the LEAP methodology also ask for determining ecosystems and their integrity and importance at each location. Ideally, detailed information on the condition of species and ecosystems is available. However, most often this information is not available and will also be difficult to easily monitor.

As an indicator of ecosystem integrity, we applied the ABC-Map. The Adaptation, Biodiversity and Carbon Mapping Tool (ABC-Map) is a new geospatial tool based on Google Earth Engine that holistically assesses the environmental impact of National Policies and Plans (NDC, NAPs, etc) and investments in the AFOLU sector. It is being developed by FAO and it combines the data from the ESVD with, for example, the MSA (Mean Species Abundance) index.

The current version provides detailed statistics on the pressure level that biodiversity is facing in the selected locations, the Mean Species Abundance (MSA). The MSA can range from 0, meaning a maximum disturbance, to 1, a fully undisturbed biodiversity. The assessment in the ABC-Map is based on satellite data and can be carried out at a detailed spatial resolution (ranging from 10 by 10 up to 300 by 300 meters). Figure 8, Figure 9 and Figure 10 show the MSA for the first three case studies. The aggregate MSA ranges between 0.26 and 0.36, meaning that biodiversity in these areas is under severe pressure. Therefore, integrity of the biodiversity is relatively low.



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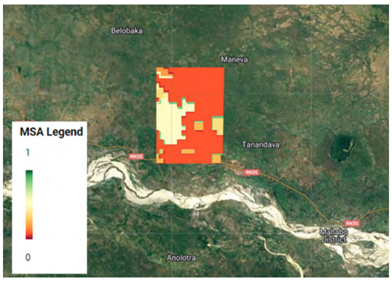


Figure 8: Aggregated MSA of the Geelders area. Average MSA is 0.26 over an area of 30 km²

Figure 9: Aggregated MSA of the Zazamalala area. Average MSA is 0.26 over an area of 28 km²

Figure 10: Paraguay case MSA =0.36, 120 km²

assess the importance of biodiversity in the region, tools like the ABC-Map can also be used since they indicate whether there are important biodiversity areas present in the area (L3). However, it is important to realize that if an area is not formally protected or an official area of high biodiversity, it does not mean that the biodiversity is not at risk and that it is not important from both an ecological and societal perspective. Three of the described cases (nr. 2, 3 and 4) are not located in a nature protected area, but as the assessments show, the landcover change has a very significant impact on biodiversity, welfare and the ecological quality of the area.

The information in the ESVD can also be used as an indicator to determine the importance of biodiversity in a specific area, also when biodiversity in the area is not protected (L2+3). If information on the ecosystem/biome type is available, the ESVD can be used to determine the bundle of ecosystem services that these ecosystems (potentially) provide to society and give an indication of the monetary value (see Box 3). Chapter 3 of this report clearly shows that natural ecosystems provide many important ecosystem services to society with a considerable monetary value. Although this indicator excludes the intrinsic value of biodiversity, the number of services and/or the monetary value could be used as an additional indicator of the societal importance.

BOX 3: INTEGRATION OF THE ESVD AND SATELLITE DATA IN THE LEAP METHODOLOGY

In the Paraguay case, we also applied satellite information developed by SarVision for assessing the integrity of ecosystems at the project location (L2+L3). Using radar and optical remote sensing, SarVision can assess a wide range of land cover and vegetation characteristics of both in and around the concession site that can be used as an indicator for changes in (the integrity of) biodiversity. It provides information about if and when a plantation has been established, what type of vegetation has been removed (biodiversity impact), and how the plantation is developing. Figure 11 shows that from 2019-2022, agricultural land was cleared and converted to eucalyptus plantations. The eucalyptus plantations are displayed on the imagery with different colors, representing the year in which the eucalyptus has been planted.

In the surrounding areas, we see dark surfaces, which correspond with dense tree coverage. These dark surfaces are natural forests or forest plantations. The images show that in the two plantation sites, there was still secondary vegetation present in 2019, i.e., before the eucalyptus was planted because it has some more dark green surfaces. The 2020 image shows that the sites have been cleared as their dark green surfaces turned into light green, and the contours of the eucalyptus plantations are visible, but there is hardly any vegetation (growing eucalyptus trees) visible yet. The 2021 image shows that the 2019 eucalyptus trees are developing fast, indicated by the dark green surfaces. In the 2022 image, the 2019 and part of the 2020 planting sites are fully covered with eucalyptus.

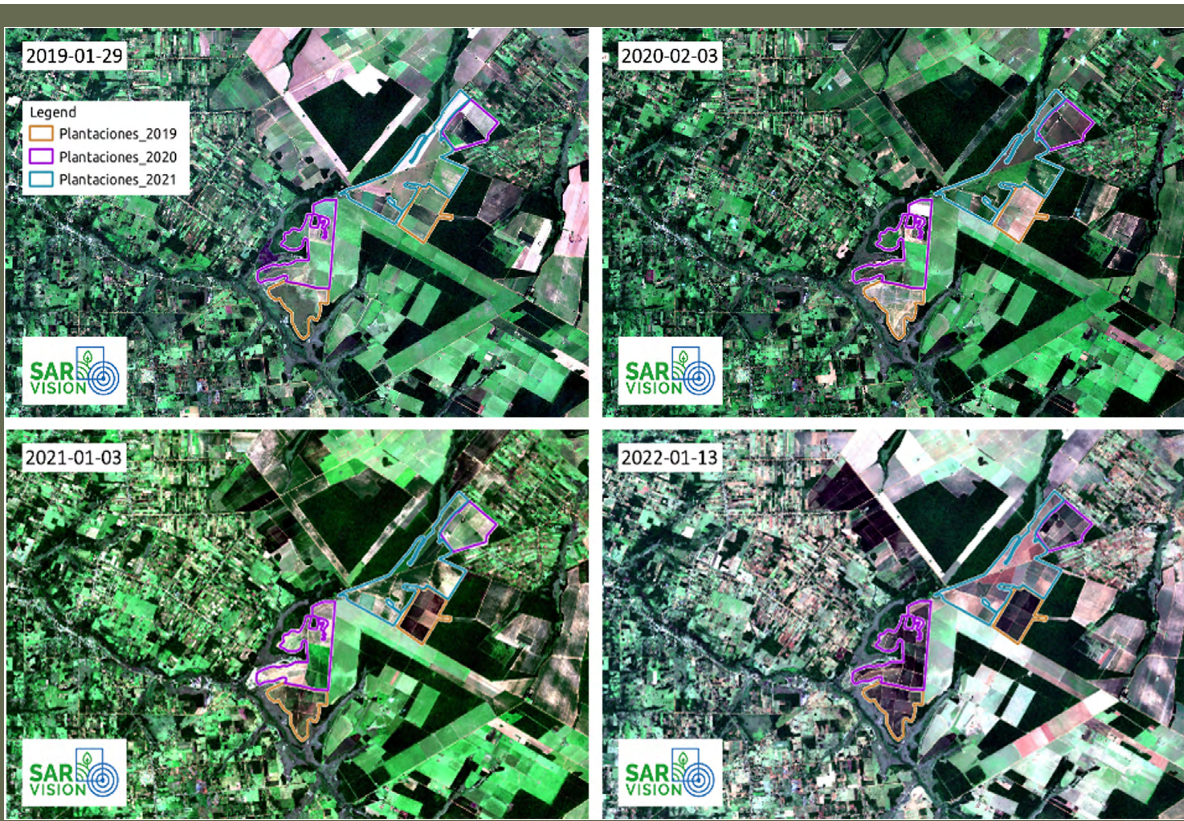


Figure 11: Sentinel-2 optical images for the years 2019, 2020, 2021, 2022 with eucalypt planting sites with different planting years for the project site in Paraguay (Source: SarVision)

With the help of this kind of remote sensing, the impact of investments on the environment can be monitored well. With additional help from the near real time, radar based, SarSentry monitoring system, deforestation and forest degradation or forest growth can be detected in and around a concession area. This newly developed system provides information that in the future can be combined with data from ESVD to assess the monetary implications of these changes and thus how it translates into various biodiversity related risks (see Section 4.3).

4.2 EVALUATE - DEPENDENCIES & IMPACTS

In step 2, Evaluate and the second group of components of the LEAP framework (E1 – E4), an evaluation of the dependencies and impacts on biodiversity is carried out.

As shown in step one, companies need to determine their business processes and activities at each location to determine what environmental assets and ecosystem services they have a dependency or impact on. In our assessment of the four cases, we showed how a change in land cover corresponds with either increases or decreases of ecosystems services and the potential change in monetary value of these services due to the investments made. This aligns well with the second group of components as the ESVD does not only provide information on the ecosystems impacted by an activity at a project location (E1- Identification of relevant environmental assets and ecosystem services by priority location + E2- Identification of dependencies and impacts by priority location), but also on the magnitude of the impact (E3+4-Dependency and impact analysis) on the social and economic welfare of different public and private stakeholders. The extent to which an organization depends on which ecosystem services at a certain location can currently not easily be measured with the ESVD. This asks for an integration of tools like ENCORE with the ESVD. If a company identifies on which ecosystems services it depends, it can use the ESVD to assess the (changes in) availability of these services to the company.

Current footprinting methodologies like the BFFI, GBS and CBF can be used to assess the potential impact of an investment on biodiversity, also on a project level. These footprinting methodologies result in an impact score showing the changes in MSA or PDF (potentially disappeared fraction of species). Moreover, these methodologies will show what drivers are likely to be responsible for this impact, and where in the value chain. This result cannot yet be linked to a change in ecosystem services. However, one of the drivers of biodiversity loss included in these footprints, land-use change, can be used to assess the (potential) impacts on ecosystem services and their value, provided the impact location is known.

4.3 ASSESS - MATERIAL RISKS & OPPORTUNITIES

When the links between ecosystem services and impacts and dependencies are known, possible risks and opportunities can be assessed, the third step and group of components of the LEAP framework; Assess - Material risks & opportunities components (A1 – A5). The TNFD identifies three risk categories: Physical risks, Transitional risks and Systemic risks. To illustrate how ESVD can be used to assess the various risk categories in accordance with LEAP, we used the risk assessment framework presented in Figure 12.

The state and trend of biodiversity is impacted by the activities of the company that is supported by the finance sector, but also by activities of other stakeholders like governments, businesses or the public. The ESVD provides insights in different stakeholder groups which might be affected and therefore what risks and opportunities an investment pertains and how these might be managed or mitigated (A2- Acknowledgement of current nature-related risk management efforts).

If information is available on the dependency of a company on ecosystem services (e.g., by using ENCORE), the ESVD is of value in assessing whether there will be a change in the provision of these ecosystem services at the relevant sites, thereby functioning as an indicator for the physical risk (A1-Risk identification). For example, coffee farms depend on pollinators for the growth of their coffee beans. If a land cover change surrounding a coffee farm, leads to deforestation of a rainforest which is home to these pollinators, the pollination service likely decreases. With the ESVD, the loss of this service is translated into a monetary value. This can be linked to company revenue data and therefore can provide an indication of the value at risk and a direction of the magnitude of the dependency.

In chapter 3, we showed that biodiversity provides many ecosystem services that all together represent a considerable, monetary, value to society. A change in biodiversity resulting from a project thus has large societal consequences through a change in ecosystem services. These consequences could be considered in assessing the four transitional risk categories (A1). In general, the higher the societal relevance (i.e., monetary value) of the ecosystem services, the higher the risk. Policy makers will be more stimulated to protect biodiversity and to put laws and regulation in place if the value of (threatened) ecosystems are high. The reputation of a company will be affected more if the value of biodiversity is high and/or if the contribution to the change in biodiversity due to the company activities is large. In case study 3, the plantation of eucalyptus potentially negatively impacts the water retention capacities of the adjacent river and the wetlands. Satellite imagery from Sarvision showed a rather large nearby river and no signs of flooding through the years. A eucalyptus plantation requires much water and is therefore likely to negatively impact the nearby water retention capacities. This impact could increase the reputational risk.

Companies should realize that even if their own impact on biodiversity is limited compared to the impact of other stakeholders, their role could still significantly impact their reputation (e.g., if people cannot see the relative contribution of all stakeholders to the biodiversity change). If it becomes clear that certain products have a negative effect on important biodiversity, the demand for other products or production processes with a lower impact might increase (technology risk) and shift demand and financing (market risk).

By using the ESVD, companies can assess to what extent other stakeholders are potentially impacted and therefore better assess the four transition risk categories in a broader stakeholder field. As tools like the ABC-Map and the ESVD are freely available, it is likely to assume that governments and other stakeholders will be able to more easily assess the societal consequences of changes in biodiversity in the regions they are interested in (see also Box 4).

The scale at which physical and transitional risks increase, will provide input in assessing changes in systemic risks. The assessment of systemic risks ideally requires a detailed risk assessment. However, this detailed assessment is often hampered because of a lack of:

1) location-information;
2) the knowledge of production and consumption chains involved;
3) information on the impact of the many stakeholders and their activities in relation to biodiversity and
4) the interconnected dynamics of ecosystems, their services and their related tipping points.

This is why a more aggregated ecosystem approach, at various spatial scales or at sector level would be very useful to get a better assessment of the systemic risk.

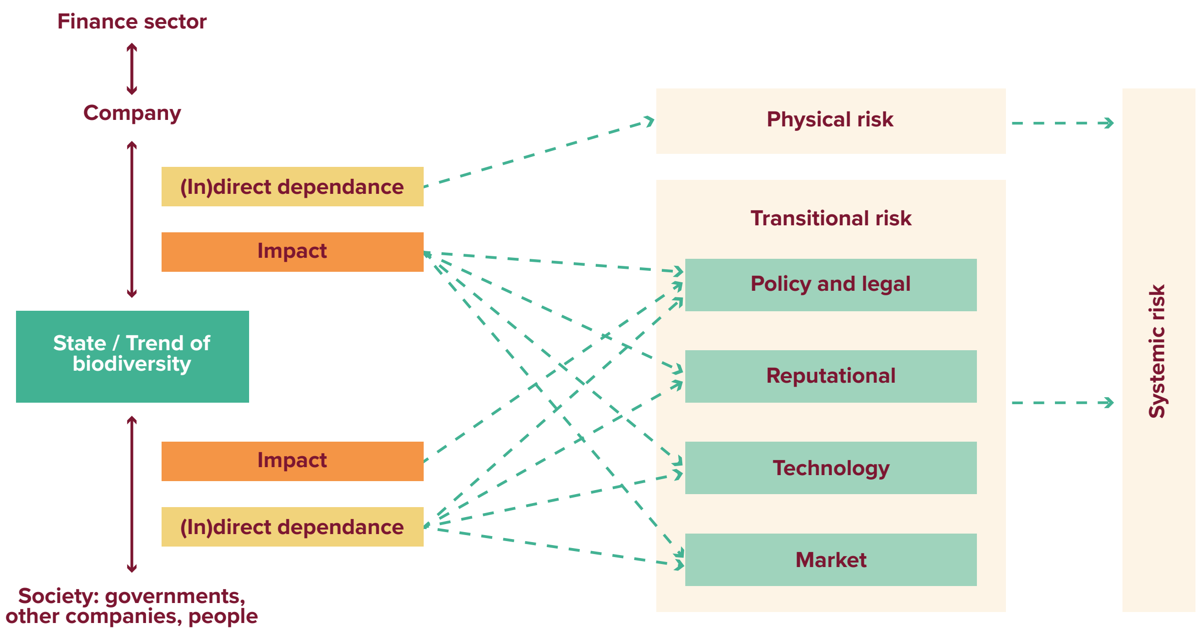
BOX 4: USING THE ESVD WITH OTHER TOOLS AND METHODOLOGIES FOR ASSESSING RISKS AND OPPORTUNITIES

Tools like the ABC-Map and data products from companies like Sarvision can determine changes in land cover and the pressure on biodiversity. By combining data from the ESVD with information on land cover changes, it becomes relatively easy to assess potential changes in the monetary value of ecosystem services provided from regional to global level. The ABC-Map has already incorporated the integration of land cover data and ESVD data and thus allows a quick calculation/assessment of the change in monetary value of any selected area on our planet.

Also, the BFFI methodology that assesses the biodiversity footprint and expresses it as the Potentially Disappeared Fraction (PDF) of species in a specific area, during a specific time as a result of various impact drivers from a company or a whole sector, can be integrated with ESVD output. As no or only limited location information is available in the calculation of the PDF, possibly a rough estimation of the monetary value of the various ecosystem services could be used to calculate the societal impact in addition to the PDF.

The assessments can be done for past and current changes in biodiversity but also for the future, using scenario studies. Global Change Assessment models like GLOBIO can assess future change in biodiversity at various spatial and temporal levels taking into account various socio-economic scenarios (population size and density, income, consumption patterns, fragmentation of natural areas, etc.). By combining these outputs of future land use changes with information from ESVD, the scale of societal impact could be assessed in more detail. These assessments would give financial organizations interesting insights in when and where systemic risks can be expected.

Figure 12: Risk assessment framework



Finally, the ESVD can also show positive changes in monetary values which can steer decisions on the positive investments (A5-Opportunity identification and assessment). The ESVD shows which ecosystems provide many services and therefore it can guide the type of nature restoration activities or nature-based solutions which should be implemented. The cases in this report show that nature restoration or nature preservation has large societal values and therefore provide opportunities for investment with innovative financial products.

4.4 PREPARE - TO RESPOND AND REPORT

The fourth step and group of components of the LEAP framework is 'Prepare – To respond and report' (components P1 - P4). They are divided in 'Strategy and resource allocation' and 'Disclosure actions '. The large diversity of ecosystem services and the large monetary value of natural systems as illustrated in Chapter 3 would require a different strategy to properly account for these values in the future. There is a need for new blended financial products that include or allow for the inclusion of ecosystem services in all location-specific investment decisions where ecosystems are impacted.

Understanding the dynamics of biodiversity and its related ecosystem services in an area and the ability to better attribute the positive/negative impact of a company on nature, requires regular, but continuous monitoring. By having a better understanding of the relevant ecosystem services, it will be 'easier' to set up these monitoring activities in a transparent manner.

5 Conclusions and recommendations

5.1 CONCLUSIONS

For all cases we analysed the effects of land cover changes on the flow of ecosystem services and their monetary value. To do these assessments properly it is important that at least information on the land cover change realized by the project is available. Furthermore, information about the location of the project is of great importance. The more precise the location of the land cover change is known, the higher the quality of analysis. Receiving access to location information appeared to be a main obstacle in the selection and analysis of the cases.

By applying different (land cover change) scenarios we were able to assess the ecological, monetary and societal consequences through changes in ecosystem services. This allows to determine trade-offs between the different scenarios, which in turn makes it possible for financial institutions and investors to better judge the possible ecosystem services outcomes of different land use planning and investment scenarios. We demonstrated that assessments based on an Ecosystem Services approach provide an essential basis for performing comprehensive risk assessments, and subsequently serve as input for discussions with stakeholders by providing better insight in the distribution of benefits and losses for different stakeholder groups.

Four main conclusions can be derived from all case studies:

1. **Including all ecosystem services in risk assessment is essential to understand the trade-offs:** an integrated ES assessment provides a comprehensive overview of all the ecosystem services that are affected by land cover change. This provides insight in both the direct effects (e.g. in terms of resources provided or lost in the investment area) and indirect effects, both on-site and off-site (e.g. through changes in regulating services affecting environmental quality and non-material benefits such as nature as a source of inspiration for culture, art, recreation, and ethical values). Better understanding of all trade-offs is essential for robust risk analysis to avoid unexpected off-site and long term effects with high costs.

2. **Monetary valuation helps to illustrate the impact of investments:** By calculating the total monetary value (or TEV) of all ecosystem services affected by the investment (positive and negative) the order of magnitude of the impact from the investment on the different ecosystem service becomes visible. Conventional Cost Benefit Analysis (CBA) usually ignore ecosystem services that have indirect market values and/ or do not calculate the economic value of ecosystem services in monetary terms. Therefore, these CBAs provide no full understanding of the impact of the investment or how the various costs and benefits relate to each other. This leads to decisions that may increase direct private revenues but sometimes at the expense of high costs that are paid for by affected stakeholders elsewhere and by future generations. Which subsequently triggers a variety of risks. Integrated ES assessment with a monetary valuation makes it possible to give 'nature' a clear place on the balance sheet and gain a better understanding of the actual magnitude of impacts and trade-offs that result from investment decisions.

3. **Nature positive investments ask for a different time perspective:** By translating the TEV of investment alternatives into a Net Present Value (NPV) over a given time period it is possible to demonstrate the impact of the choice of discount rates and time horizon on the eventual outcome of the decision. The value of public services often only becomes visible over longer time scales (asking for a low discount rate and long time scale) while most conventional investment decisions are based on high discount rates and short time scales. The case studies clearly show the need for adjustments in financial investment criteria, time horizons and contract conditions.

4. **Integrated ecosystem valuation changes the perspective on stakeholder involvement:** By looking at the distribution of benefits and losses over the different ecosystem service categories we gain insights in the stakeholders that could be influenced by the change in land cover. Understanding and knowing the stakeholders pinpoints the direction of risks but also the development of new financial products, like blended finance, where public and private finance are linked to changes in public and private services and related stakeholders.

All four main conclusions underline the urgency to take the full ecosystem perspective and value into account in financial decision making. Ultimately moving away from partial impact assessment based on a few 'key performance indicators' and truly place the full value of nature on the balance sheet. Integrated ES assessment makes it possible to provide a more complete understanding of what is actually happening 'on the ground' (to ecosystems, biodiversity and people), what the influence is of the time horizon of the investment, who the (local) stakeholders are, and subsequently which risk categories are potentially triggered. This understanding helps to build a more robust investment case and secure more, truly sustainable investments and supports the development of new financial products such as blended or transitional financing mechanisms.

Integrating ES assessment into Risk Assessment strengthens the investment case for biodiversity-positive investments. All our cases showed a positive effect on the flow of ecosystem services although most of the economic benefits are not acknowledged (yet) in the market (except for carbon credits). It shows that we need to demonstrate (to investors) that the economic value of ecosystem services does not always result in a direct financial return on investment (many ecosystem services are not yet traded in markets) but that the return can be captured by innovative investment schemes such as 'payments for ecosystem services' (PES) and 'blended finance' approaches involving the beneficiaries of the investment in long term financing arrangements.

Other findings from our pilot studies

1. In all case studies, expanding the natural area leads to a strong increase in the flow of ecosystem services. Monetary valuation of ecosystem services, supported by the ESVD, made it possible to quickly identify the most relevant ecosystem services for the various case studies and made the importance of the non-market services visible. This is important because provisioning services are mainly provided in agricultural areas, while regulation, habitat and cultural services are mainly provided by more natural ecosystems.

2. We found that the TEV of a hectare of natural ecosystems is in most cases higher than the TEV of a hectare of agricultural land. However, monetary data is still lacking for many ecosystem services provided by natural ecosystems. As a result, the values presented in this report are most likely an underestimation of the 'true value'. Consequently, the societal benefits of restoration investments are probably even higher than shown in this report.

3. For consistency among the case studies we chose a time period of 10 years and discount rate of 5% for calculating the NPV. Since the effects of positive biodiversity impact projects usually only slowly develop, the choice of the time horizon and discount rate has a big influence on the outcome of the assessment.

4. The case studies illustrate the complexities of analysing effects of land cover changes, especially when it involves a variety of ecosystems. These complexities highlight the importance of better understanding all trade-offs and involving the stakeholders impacted when one wants to assess potential systemic risks.

About risk assessments and the LEAP framework

Quantifying change in ecosystem services and the monetary consequences in a location specific context is crucial to arrive at better risk assessments. The LEAP methodology of the TNFD endorses this importance for both the company or project being invested in as well as for society at large. In our pilot assessments, we clearly show that a change in ecosystem services not only affects the physical risks of the company, but also affects other stakeholders. The TEV and NPV calculations highlight that different ecosystem service categories impact different stakeholder groups. Provisioning services in an agricultural system usually benefit only private stakeholders because these services can be sold on markets. Regulating and habitat services, which usually cannot be traded in markets and are mainly provided by 'natural ecosystems', benefit a much larger array of stakeholders, including private and public stakeholders. Cultural services also benefit a large variety of stakeholders and can sometimes be reflected in market prices. The ES approach makes the different interests of stakeholders visible and thereby also provides a more complete picture of the investment risks.

About satellite information

We also found that satellite data is highly instrumental in quantifying location-based land cover changes and changes in the condition of ecosystems. Satellite data also makes it possible to quantify indicators for the pressure on biodiversity in a given area. Ecosystems and their services are dynamic and influence each other. When you change the provision and use of one service you potentially influence all services. Although we are not able to oversee all the trade-offs on an ecosystem service level yet, we do see that by using satellite and remote sensing data we can gain a better understanding of the context in a specific location which allows for better analysis of investment risks.

The ESVD makes it possible to give a first quick estimate of the order of magnitude of monetary values involved in the investment on the basis of standardized data. However, for more precise and robust data, local studies to collect empirical data are necessary. Performing such local studies usually faces constraints with regards to available time, funding, data and expertise. ESVD data helps to provide a first estimate and pin-point the most relevant data gaps for better impact and risk assessments.

5.2 RECOMMENDATIONS

This project has yielded many new insights. The following recommendations can be considered in further development of the use of ES assessment in integrated Risk Assessment.

1. More case studies will be essential to further improve the assessment methodology, the alignment with other tools and methodologies such as TNFD's LEAP approach, ENCORE and impact assessment methodologies like the BFFI, and will stimulate the expansion of databases like the ESVD. It will also facilitate communication with stakeholders to further develop the application of the methodology and to increase the understanding of, and support for, integrating ecosystem services and their monetary value in investment decisions and project evaluation.

2. More detailed insights and discussions are needed on how information on TEV and NPV of natural (restored) areas could be integrated in the set of (sustainable) investment criteria currently used by financial institutions. This information can also be used to determine specific contract conditions for biodiversity positive investments. Adjustments, such as longer project timelines (to allow the ecosystems to unfold their full ES potential), or variable discount rates (to account for the increase in value of the natural capital in restoration projects), should be taken into consideration in the design of the investment case.

3. Changes in land cover always lead to a change in the number, nature and magnitude of the ecosystem services potentially provided. This change may influence a large number of stakeholders affected by and/or having an interest in these services. For our case studies it was difficult to link ecosystem services to specific stakeholders because location-specific information was often lacking. Ideally, an inventory should be made of the main stakeholders per land cover type and ecosystem service. This will help the process of identifying who needs to be involved in assessing risks and opportunities, the quantification of the monetary value of ecosystem services, or the development of new financial products.

4. Adding ecosystem services and their monetary value to decision-making procedures requires setting quality standards for the information that is needed to perform robust risk analysis. An example of such a standard, focusing on biodiversity impact and dependency assessment, is the PBAF Standard (Partnership for Biodiversity Accounting Financials). These quality standards should be developed by a multidisciplinary team in which the variety of stakeholders is represented.

5. Expansion of the datapoints in the ESVD database is needed to make the (ex-ante and ex-post) assessment of the monetary value of ecosystem services more robust.

6. Development of value transfer functions is needed to make transferring values between sites more robust by enabling predicted values to reflect local demand (e.g., number of beneficiaries, presence of other ecosystems) and supply factors (e.g., size and condition of the ecosystem). Socio-economic variables such as proximity to urban areas or roads, GDP, condition of ecosystems or proximity to other ecosystems will influence the monetary value of most ecosystem services.

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Appendix 1 – Case study explanation

To explain the calculations made in the risk assessment, this appendix gives insight in the calculations for case study 1 (restoration of a forest in the Netherlands) as example.

CASE STUDY 1: TREES FOR ALL – RESTORATION FORESTS IN GEELDERS

Step 1: Understanding the context

Trees for all will, together with ARK, plant 40 ha of forests between 2020-2024 to increase the amount of loam forests (leembossen) in the Geelders, a forest reserve in the province North-Brabant. Plots of a agricultural land will be bought and will be converted into loam forests. Loam forests are forests on a loam substrate, which is a soil layer about 2 meter in the soil through which water cannot move. This means that in the fall and the winter, there is a likelihood that the forest will stand in water for several months.

Figure 13: Nature area the Geelders (Source: Google Earth)

Step 2: Translation into ESVD biomes/ecosystems

- **Forests**
  - A special ecosystem, namely Loam forests. The ESVD contains no specific data on these forest ecosystems, most up to date no valuation data exists for loam forests.
  - Therefore, after discussion with experts (Dolf de Groot and Arnold van Vliet), we have chosen for Temperate deciduous forests (for England) because this ESVD classification most closely resembles loam forests
- **Agricultural area**
  - Background information from Trees for All mentions corn and pastures. Therefore, these two ecosystems were chosen.

Step 3: Calculation of standardized values

- Forests: Generally, there were sufficient monetary values for the assessment of deciduous forests (data from England).
- However, there were several special cases
  - Erosion control: Coming from Asian data (not England) on deciduous forests because there was no European/England data while erosion control is a well-known service provided by forests.
  - Data recreation: Very high value of non-monetary valuation of the Geelders in Atlas Natuurlijk Kapitaal (ANK), so average of the 2 highest values in the ESVD, value ID's 9320004-5
  - No data of pollination, biological control, maintenance of life cycles + diversity and inspiration for culture for deciduous forests, while most likely this is provided. Marked in grey/blue

Standardized values are the average of all the different monetary values per ecosystem service. If a service has two monetary values for food, the average will be the summation of these monetary values divided by two. This leads to the following standardized values for forests:

Services	# value estimates	Standardized value
Food	2	$1
Water		
Raw materials	8	$38
Genetic resources		
Medicinal resources		
Ornamental resources		
Air quality regulation	301	$1,580
Climate regulation	5	$306
Moderation of extreme events	1	$6
Regulation of water flows	1	$121
Waste treatment		
Erosion prevention	2	$177
Maintenance of soil fertility		
Pollination		
Biological control		
Maintenance of life cycles		
Maintenance of genetic diversity		
Aesthetic information		
Opportunities for recreation and tourism	2	$371
Inspiration for culture, art and design		
Spiritual experience		
Information for cognitive development	1	$200
Existence, bequest values	6	$2,492
Total	**329**	**$5,292**

- **Cultivated areas**
  - Provisioning services coming from publicly available information on market prices for snijmais (most common corn) and fodder.
  - Additional service: Aesthetic information and inspiration for culture, art and design
    - Rational because cropland has a historical value and it has been an inspiration for art in NL etc.
  - No disservices taken into account
  - Summary value based on combined average market prices for pastures (grass price 2018) & corn (2021).

This leads to the following standardized values for cultivated areas:

Services	# value estimates	Standardized value	Total value
Food			$ -
Water			$ -
Raw materials		$ 2,329	$ 93,168
Genetic resources			$ -
Medicinal resources			$ -
Ornamental resources			$ -
Air quality regulation			$ -
Climate regulation			$ -
Moderation of extreme events			$ -
Regulation of water flows			$ -
Waste treatment			$ -
Erosion prevention			$ -
Maintenance of soil fertility			$ -
Pollination			$ -
Biological control			$ -
Maintenance of life cycles			$ -
Maintenance of genetic diversity			$ -
Aesthetic information	2	$ 0.3	$ 12
Opportunities for recreation and tourism			$ -
Inspiration for culture, art and design	4	$ 3	$ 107
Spiritual experience			$ -
Information for cognitive development			$ -
Existence, bequest values			$ -
Total	6	$ 2,332	$ 93,287

Step 4: Calculations of TEV and NPV

To calculate the TEV, as mentioned in the methodology chapter, the standardized values are multiplied by the total number of hectares, namely 40 hectares. This leads to the following TEV:

Services	Scenario 1: Current agriculture	Scenario 2: Future forests
Provisioning services	**93.2 K**	**1.6 K**
Food	$0	0.03 K
Water	$0	$0
Raw materials	93.2 K	1.5 K
Genetic resources	$0	$0
Medicinal resources	$0	$0
Ornamental resources	$0	$0
Regulating services	**$0**	**87.6 K**
Air quality regulation	$0	63.2 K
Climate regulation	$0	12.2 K
Moderation of extreme events	$0	0.2 K
Regulation of water flows	$0	4.8 K
Waste treatment	$0	$0
Erosion prevention	$0	7.1 K
Maintenance of soil fertility	$0	$0
Pollination	$0	$0
Biological control	$0	$0
Habitat services	**$0**	**99.7 K**
Maintenance of life cycles	$0	$0
Maintenance of genetic diversity	$0	$0
Existence. bequest values	$0	99.7 K
Cultural services	**0.1 K**	**22.8 K**
Aesthetic information	0.01 K	$0
Opportunities for recreation and tourism	$0	14.8 K
Inspiration for culture. art and design	0.1 K	$0
Spiritual experience	$0	$0
Information for cognitive development	$0	8.0 K
Total	**93.3 K**	**211.7 K**

The NPV is calculated for 10 years. As the Trees for All projects takes place from 2020-2024, it is assumed that for 5 years, 8 hectares are reforested per year. Therefore, only in year 5, the total area is assumed to be reforested. To calculate the NPV, the TEV per ecosystem service is multiplied by a yearly discount rate. The accumulated TEV for 10 years then makes the NPV:

Services	Scenario Agriculture	Scenario Forests
Provisioning services	**$ 719,419**	**$ 9,181**
Food	$ -	$ 202
Water	$ -	$ -
Raw materials	$ 719,419	$ 8,979
Genetic resources	$ -	$ -
Medicinal resources	$ -	$ -
Ornamental resources	$ -	$ -
Regulating services	$ -	$ 517,274
Air quality regulation	$ -	$ 373,155
Climate regulation	$ -	$ 72,284
Moderation of extreme events	$ -	$ 1,418
Regulation of water flows	**$ -**	**$ 28,641**
Waste treatment	$ -	$ -
Erosion prevention	$ -	$ 41,777
Maintenance of soil fertility	$ -	$ -
Pollination	$ -	$ -
Biological control	$ -	$ -
Habitat services	**$ -**	**$ 588,769**
Maintenance of life cycles	$ -	$ -
Maintenance of genetic diversity	$ -	$ -
Existence, bequest values	$ -	$ 588,769
Cultural services	**$ 919**	**$ 134,776**
Aesthetic information	$ 94	$ -
Opportunities for recreation and tourism	$ -	$ 87,562
Inspiration for culture, art and design	$ 825	$ -
Spiritual experience	$ -	$ -
Information for cognitive development	$ -	$ 47,214
Total	**$ 720,338**	**$1,250,000**

Appendix 2 – Classification of ecosystem services

As described in Chapter 1, ecosystem services can be classified into different overarching groups of ecosystem services:

- **Provisioning services** are the products or resources that can be harvested or extracted from ecosystems (e.g., food and raw materials).
- **Regulating services** are the benefits obtained from ecosystem processes that maintain environmental conditions beneficial to individuals and society (e.g., climate regulation, air quality, flood protection, biological control, pollination).
- **Habitat services** are the benefits provided by protecting a minimum area of natural ecosystems to allow evolutionary processes needed to maintain a healthy gene pool and by providing essential space in the life cycle of migratory species, many of which have commercial value elsewhere (notably the nursery service of mangroves and other coastal systems).
- **Cultural services** are the experiential and intangible benefits related to the perceived or actual qualities of ecosystems (e.g., spiritual enrichment, cognitive development, recreation, aesthetic enjoyment, and the appreciation of the existence of diverse habitats and species).

The ESVD ecosystem services classification, based on The Economics of Ecosystems and Biodiversity (TEEB) (De Groot et al, 2010), recognizes 23 ecosystem services:

Provisioning	
Food	e.g. fish, game, fruit
Water	e.g. for drinking, irrigation, cooling
Raw materials	e.g. timber, fiber, fodder
Genetic resources	e.g. for crop-improvement and medicinal purposes
Medicinal resources	e.g. biochemical products, models & test-organisms
Ornamental resources	e.g. artisan work, décorative plants, pet animals, fashion

Regulating	
Air quality regulation	e.g. capturing (fine)dust, chemicals, etc
Climate regulation	incl. C-sequestration, influence of vegetation on rainfall, etc
Moderation of extreme events	eg. storm protection and flood prevention
Regulation of water flows	e.g. natural drainage, irrigation and drought prevention
Waste treatment	especially water purification
Erosion prevention	
Maintenance of soil fertility	incl. soil formation
Pollination	
Biological control	e.g. seed dispersal, pest and disease control

Habitat	
Maintenance of life cycles	incl. nursery service
Maintenance of genetic diversity	especially gene pool protection

Cultural	
Aesthetic information	Beauty of a landscape
Opportunities for recreation and tourism	e.g. active immersing
Inspiration for culture, art and design	
Spiritual experience	
Information for cognitive development	Educational activities
Existence, bequest values	e.g. preservation for future generations

For more information, see the publication by De Groot et al (2010).