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Nature related financial risks assessment in portfolio management

Cheikh Abdellahi Cheikh Abdellahi

► **To cite this version:**

Cheikh Abdellahi Cheikh Abdellahi. Nature related financial risks assessment in portfolio management. Business administration. 2021. dumas-03551995

HAL Id: dumas-03551995

<https://dumas.ccsd.cnrs.fr/dumas-03551995v1>

Submitted on 2 Feb 2022

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**Nature related financial risks
assessment in portfolio
management.**

**Presented by: CHEIKH ABDELLAHI
Cheikh Abdellahi**

**University advisor: Professor GIRERD-POTIN
Isabelle**

**Master 2 Finance
Program Advances in Finance and Accounting (AFA)
2020 - 2021**

Preface:

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INTRODUCTION

For more than 20 years, the question of the environment has arisen more and more in the world of Finance, which has led to the implementation of ESG scoring, and the obligation of companies to report their impacts on the environment. This has helped investors, regulators, and researchers to identify the interactions between the environment and the financial system, which is essential to quantify and assess environmental risk.

Environmental threats include biodiversity loss, water scarcity, ocean acidification, chemical pollution and zoonotic disease transmission.

From an economic point of view, environmental breakdown will cause supply shocks, demand shocks and systemic effects. The financial system is exposed to the environmental dependencies and impacts of businesses through its lending, investing and advisory activities, there exists a strong relation between financial system and environmental threats, for example Banks facilitates sometimes activities that contribute to the environmental degradation.

Human activities are harming the nature, the financial risks of biodiversity loss and land degradation begin with human activity that drives nature loss.

As nature declines:

1. Natural capital is impacted and put at risk
2. Ecosystem services on which companies depend are reduced

3. These companies are recipients of finance. Their vulnerability to an ecosystem service decline is therefore a vulnerability to investors, lenders, insurers, governments, connected companies and, by extension, a source for potential financial instability. These are physical risks.

Parallel to physical risks, transition and liability risks emerge, such as policies to protect nature. Despite their positive impact on nature, such policies can cause an economic harm to some companies and, in turn, those financial institutions (FIs) connected to them.

Physical, transition and liability risks can drive a reorientation of portfolios and economic activity. As a result, financial flows could be redirected to boost the ecosystem services that provide benefits to people and drive a transition to a nature-positive economy,

To measure and manage this risk, we need the collaboration of regulators, investors, researchers ... regulators must limit the possibility of banks to finance activities that harm nature. For investors and researchers, the objective is to develop robust tools to quantify this risk.

This research topic is part of the financial system's participation in reducing environmental damages. After the recent financial crises, many people have lost confidence in financial markets and consider them a main cause of social inequalities and environmental risks. Recently Banks have implemented sustainable financial products such as green bonds but this is insufficient to limit the environmental degradation.

With covid 19, social inequalities have accelerated, companies have gone bankrupt, states are over-indebted. This pandemic is the trigger for environmental risk alarms. Finance is today the main player in ensuring sustainable development.

Any activity harmful to biodiversity is first financed and therefore the role of the financial system is essential in reducing the impact on the environment.

The interest of this subject lies in the desire to identify feasible methodologies for measuring environmental related financial risk. the main research question is therefore:

How to quantify Nature Related Financial Risks?

Taskforce for Nature-Related Financial Disclosures (TNFD) proposed a market fixing methodology to quantify natural risk, but this approach is insufficient for capturing the systemic risk of environmental breakdown for two reasons: absence of natural price signals and even this signal exists, financial markets are incapable of sufficiently internalizing Nature Related Financial Risk (NRFR) into prices, due to the multi-dimensional complexity and radical uncertainty that characterizes environmental breakdown.

There is already a tool used for several years by almost most investors to assess the environmental factor of a company, it is the ESG. Rating agencies give scores to companies regarding three factors: Environment, Sociability and Governance, offering an essential

service for any investor wishing to include the ESG strategy in his portfolio. So **why do actors want other and more robust tools to measure NRFR?**

In the first part of this thesis, and after having identified the interactions between environment and financial system, and what are the NRFR for an investor, we will explain why we consider that the ESG is not designed to capture the NRFR. we will be based on several examples and the MSCI methodology.

We will then present recently developed tools which can be very useful to measure the environmental risk, for example ENCORE and GBS.

Exploring Natural Capital Opportunities, Risks and Exposure (ENCORE) was developed by the Natural Capital Finance Alliance to help users better understand and visualize the impact of environmental change on the economy. It covers 11 sectors and 167 subindustries classified according to the Global Industry Classification Standard (GICS) and 21 ecosystem services, classified based on the Common International Classification of Ecosystem Services (CICES).

Global Biodiversity Score (GBS) was developed by CDC Biodiversité to give a score to companies regarding their dependence and impact on biodiversity.

These two tools are different, the first is interested in the question of nature in its entirety and provides sectoral data, for example, a certain sector depends highly on a certain ecosystem service. It is not a score but a description of dependencies and impacts.

The GBS gives a score to the company regarding its biodiversity footprint, it is based on financial data or on reports drawn up within the company, this tool is particularly interested in an aspect of the environment which is the Biodiversity.

In the second part of this thesis, we will present the possible methodologies to quantify this risk, the advantages, and limitations of each methodology.

We will not be able to test empirically the methodologies due to lack of Data, but we will present the model and explain how it can be used.

PART I :

-

LITERATURE REVIEW

In this part, we will present the main writings dealing with NRFR, major reports are written by financial institutions and consulting firms, few academic reports.

In the first chapter we will focus on the interdependences between nature and the financial system, this will allow us to have a panoramic vision of the different aspects of the research question, then we will focus in a second chapter on one aspect of the NRFR which is the biodiversity related financial risk.

In this chapter we will also present the Natural Capital Protocol to assess the biodiversity risk, the biodiversity footprint approach and explain why ESG is insufficient to capture the nature related financial risk. This second chapter is very important to introduce the second part, which will be consecrated to the methodology.

CHAPTER 1 – NATURE AND FINANCE

Over the past 15 years, financial institutions have become progressively responsible for economic activities having an impact on nature through the different funding they grant to these activities. Likewise, they are exposed to natural risks that will affect the economy and subsequently impact investors and financial institutions.

Globally, Financial institutions have played a key role in the global mobilization on the climate through various initiatives (individual or broad-based coalition). They made a significant progress to assess climate related financial risk. Finding the link between financial institutions and nature is both urgent and complex, it is necessary to learn from the lessons learned from the way financial institutions gradually mobilized for the climate. Assessing NRFR is urgent and complex, and need to understand deeply the link between nature, real economy, and financial system.

I. NRFR AND REAL ECONOMY

According to (Raworth 2012)¹, the economy and the environment cannot be separated, on the contrary the world economy depends heavily on nature. Economic and human activities generally benefit from the free services of nature, natural capital and ecosystem services allow us to benefit from renewable or non-renewable natural resources. For example, healthy forests provide clean air, insects for pollination etc.

These ecosystem services are essential for the continuity of life on earth, it is therefore our duty to collaborate and put in place the necessary means to preserve them, and as we have already shown, financial institutions have the most important role to play. Damaging or not maintaining this natural system can lead to dire consequences.

The real economy will be impacted via three channels:

- ✚ Supply shocks: firms and sectors that depend on ecosystem services (eg agricultural firm) will be negatively impacted by environmental changes, which will lead to current supply shocks. With the globalization of the economy, these shocks will impact the whole sphere and other sectors which depend on these sectors indirectly will also suffer.

¹Raworth, K. (2012). A Safe and Just Space for Humanity: Can we live within the doughnut? [Online]. Oxfam.

- ✚ Demand shocks: companies with a significant negative impact on the environment (eg mining) will probably have demand shocks. These shocks are caused by changes in customer preference, regulation, or technology. In addition, these companies are exposed to the risk of litigation if their responsibility for environmental degradation is proven.

- ✚ Systemic effects: environmental degradation will impact other companies indirectly, all those in the supply chain. Disruptions to production or the supply chain linked to environmental risks have already increased by 29% between 2012 and 2020 (WEF 2019)².

As covid 19 has shown, responding to crises can generate complex and unpredictable socio-economic costs.

An analysis carried out by financial institutions showed that the following sectors: (food and beverages, metals and mining, oil and gas, utilities, forestry, construction, and transportation) are the most exposed to environmental risks (McCraine et al. 2019)³. At the same time, most of these sectors especially the primary production industries are responsible for the majority of the negative impacts on the environment (Trucost 2013)⁴.

For a business exposed to supply shocks and demand will suffer financially. These shocks will result in an increase in the cost of capital (investors will require an additional premium), or difficulties in borrowing from banks. All of these will increase the risk of bankruptcy.

The companies and sectors which contribute the most to the collapse of the environment must change their interactions with the natural system and think of more sustainable activities, these same companies must review their economic models, modify them to resist environmental changes. The only way to do this is to find a way to include the unpredictable and difficult to quantify environmental risk.

New perspectives are beginning to influence such a transition. In this regard, we will cite the concept of circular economy, to minimize the linear flow of energy, material inputs and the development of closed-loop production and technological innovation in the collection and transformation of end-of-life products.

² WEF. (2019). Global Risks Report 2019 [Online]. Geneva: World Economic Forum.

³McCraine, S., Anderson, C., Weber, C. and Shaw, M. (2019). The Nature of Risk. A Framework for Understanding Nature- Related Risk to Business [Online]. World Wildlife Fund. The Nature of Risk: A Framework for Understanding Nature-related Risk to Business

⁴ Trucost .(2013). Natural Capital at Risk. The Top 100 Externalities of Business. [Online]. Trucost and TEEB for Business Coalition.

Reforming the business-nature interface represents a significant transformation in the structure of modern economy and it will be possible only if the financial system plays the role needed.

II. NRFR AND THE FINANCIAL SYSTEM

The financial system is highly exposed to environmental risks, lending, investment, and advisory activities are the vectors of this exposure. NRFRs and climate risks are similar in their systemic aspect and complexity, their effects on the financial system are also similar. It is known today that the degradation of the environment will cause a systemic risk to finance, on the other hand, one often does not consider the facility which the finance grants to the economic activities which are harmful to nature. This concept of double materiality was recently used by the European Commission in its Non-Binding Guidelines on Non-Financial Reporting for corporates, to encompass both financial materiality (impacts from the external world on the financial value of a company), and environmental and social materiality (impacts of the company's activities on the external world). TCFD is the most active initiative in green finance today, and only focuses on climate risks, TNFD, will focus only on exposures and not impacts.

The Dutch central bank (De Nederlandsche Bank - DNB) recently studied the interactions between nature and the financial system, this study revealed the extent of financial risks associated to the environment. A quantitative analysis showed that 36% of the portfolios of Dutch financial institutions were highly or very highly dependent on at least one ecosystem service (DNB 2020)⁵. The DNB has also shown that the biodiversity footprint of Dutch financial institutions (i.e. the impact on biodiversity) represents a loss of more than 58,000 km² of pristine nature, an area vastly larger than that of Netherland.

The assumption that investors optimally allocate capital in financial markets has been widely criticized after the global financial crisis, and since then central banks have increasingly intervened in a regulatory role. This connectivity and globality of markets make the financial system more and more linked and complex, which could amplify environmental risks, and for example the fall in the value of a key asset could result in a global financial shock.

⁵ DNB. (2020). Indebted to nature Exploring biodiversity risks for the Dutch financial sector [Online]. De Nederlandsche Bank.

Financial system-induced volatility has also been observed in global food markets, where the increased presence of speculative interest in commodity derivatives has been linked to greater food price volatility. Similarly, countries whose economy depends on the export of agricultural products, whose activity itself depends on pollination, soil fertility, and other ecosystem services, are vulnerable to environmental risks, the market of sovereign debt is liable to be troubled by these environmental risks (Pinzón and al 2020)⁶.

At a higher level, some financial institutions invest in activities that are very harmful to nature, these activities are very profitable, land and particularly agricultural land have become very attractive after the financial crisis, due to their returns on capital, their hedging role and also the absence of correlations with the equity markets.

The attractiveness of agriculture as an alternative investment asset is proof of the extension of finance towards the environment, or the financialization of the environment. Indeed, the rise of agricultural real estate investment trusts (REITs), which pool income streams from various farm properties, embodies such financialized logic, representing a step towards land securitization.

The transformation of natural areas into agricultural land subsequently constituting an alternative investment asset shows the rivalry between finance and sustainability, the financial markets tend to be short-term, in fact private investors suffer from this same myopia, they favor short-term rather than long-term returns. And so, the land is overused immediately to maximize its productivity by using chemicals, which in the long run affect soil fertility and the ecosystem in general.

An empirical analysis showed the increase of foreign direct investments in the agricultural sector in Latin America and south-east of Asia, which increased the area of agricultural land, this is of course a main cause of deforestation (Ceddia 2020)⁷. Meanwhile, complex financial structures, such as securitization, arguably further impede sustainability governance by lengthening and obscuring the chain of information disclosure and investor stewardship.

⁶ Pinzón, A. and Robins, N. (2020). The sovereign transition to sustainability. Understanding the dependence of sovereign debt on nature [Online]. LSE Grantham Research Institute on Climate Change and the Environment.

⁷ Ceddia, M.G. (2020). The super-rich and cropland expansion via direct investments in agriculture. *Nature Sustainability*, pp. 312–318.

The search for alternative assets to invest in and the race for returns reveals an uncomfortable truth about private finance and its inability to protect nature.

Unlike financial products allowing the reduction of climate risk, and which were generally profitable for investors, those allowing the protection of nature may not generate monetizable returns in the conventional sense of the term, which will make the mission more difficult.

Another aspect of environmental protection relating to economic activities, these must reduce and therefore the immediate consequences can lead to economic and financial shocks, but if we look at the long term the benefits are very motivating, such as flood defenses, carbon sequestration, pollinators ...these benefits are not yet monetizable, but important for the reconstitution of natural areas.

The low returns in the short term, the high transaction costs and the lack of prediction are the main constraints for investors, if we evaluate the investment in environmental protection in the risk-return framework, it is not the best reasonable investment.

A recent study carried out by (Suttor-Sorel and Hercelin 2020)⁸ has shown that market-based tools such as ESG, dependency accounting and impacts on nature ... are ineffective in orienting private finance towards projects of environmental conservation.

Despite this, this method of financing remains the most promising approach in order to preserve the environment.

The dependences and impacts on nature and the need to transition into a more sustainable finance create many nature related financial risks for financial institutions.

III. NRFR: SOURCES AND TRANSMISSION CHANNELS

There are several sources of natural risks, it can be a physical risk, a transitional risk or liability risk, the transmission channels are at the company level but also at the macroeconomic level.

⁸ Suttor-Sorel, L. and Hercelin, N. (2020). Nature's Return Embedding environmental goals at the heart of economic and financial decision-making [Online]. Finance Watch.

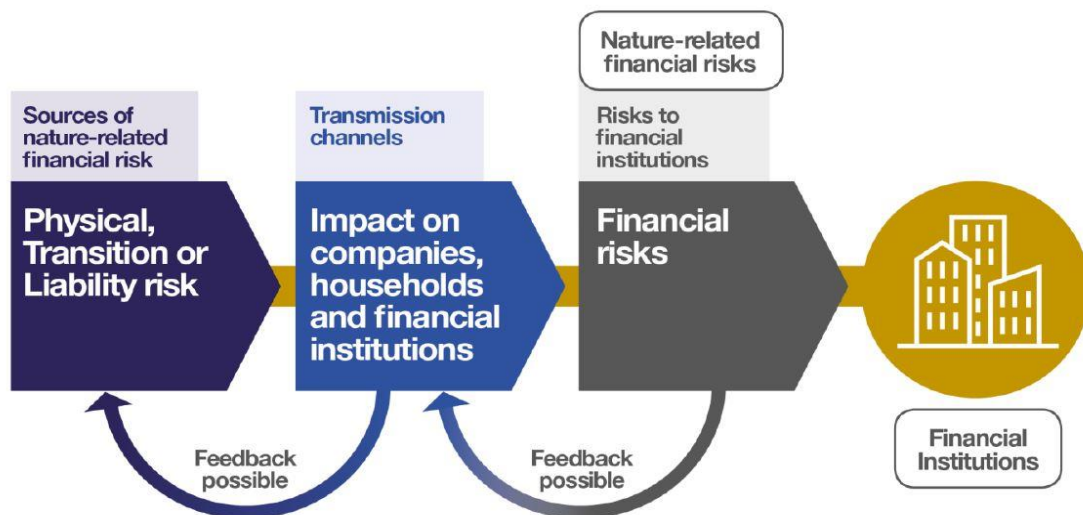


Figure 1 : Sources of NRFR

Source: Handbook for Nature-related Financial Risks Key concepts and a framework for identification

1.3.1) Sources of NRFR

- ✓ Transition risk: a company may face risks associated with its transition to greener economic activities, this risk may manifest itself in the form of changes in laws and regulations, in technologies and in the market more generally. It can turn into a reputational risk. In order to preserve the environment, the authorities respond by passing laws, which may for example prohibit access to certain natural areas, obligation to publish the dependencies and impacts of a company on nature, or the establishment of a new, stricter taxation of activities deemed harmful to the environment. Companies impacted by these changes may face very significant costs or litigation risks if the company does not comply with these changes. Technological innovations towards more sustainable technologies can be a risk for fossil-fuel-based systems and disrupt their businesses. The transition to a more sustainable economy will certainly change the preferences of the consumer, which can be very costly for the companies concerned.
- ✓ Physical risk: Most economic activities depend directly or indirectly on ecosystem services or natural capital. Environmental degradation puts companies at risk. For example, climatic changes (extremes of weather) can disrupt the supply chain, which is vital for certain activities.
- ✓ Liability risks: legal cases resulting from environmental degradation and non-compliance with laws and regulations.

Those who are victims of environmental changes can seek compensation from those responsible for degradation in the event of natural losses. These compensations can be in the form of payments, administrative and legal costs, cost of insurance ...

- ✓ Systemic risk: The systemic risk represents the global impact of the markets due to one or more of these risks, the complexity and interdependence of financial markets makes the impact of this risk very high. Systemic risk includes the exogenous biodiversity risk to the smooth functioning of the financial system as well the risk created endogenously by the financial system.

1.3.2) Transmission channels

The transmission channels can be classified into two categories: Macro and Micro channels, the following list is not exhaustive but includes the main transmission channels

Micro transmission channels	Macro transmission channels
Disruption of activities/value chains	Stranded assets
Raw materiality price volatility	Adjustment/ relocation of activities
Pricing externalities	Capital destruction

Table 1: Transmission channels of NRFR

- Disruption of activities/value chains: Disruption could be due to business interruption changing costs, changing demand, labor market frictions... The disruption of the activity or the value chain has very costly consequences for the company, resulting in an increase in current costs, in the short term, a significant reduction in working capital, as well as access to the debt. This reduces the company's ability to repay these debts, leading to an increase in the probability of default.
- Raw materiality price volatility: Fluctuations in commodity prices are an important channel for NRFRs. Significant volatility in the price of raw materials can impact the supply chain, which will disrupt the production chain, especially if initial stocks are low as it was the case for grain in 2006. Commodity price risk is material: "commodity price swings are the second-largest driver of earnings uncertainty at publicly-traded companies."⁹ It is also especially relevant to banks offering hedging and trade finance products.
- Pricing externalities: it means accounting for the economic, social and/or environmental impacts of the activities of an entity. companies are generally not the ones paying the cost of these impacts, but now and with very ambitious initiatives such as TFND, the cost of doing business to the detriment of nature is increasing more and more, Taxes on nitrogen fertilizer to reduce water pollution is a relevant example.

⁹ Rechtsteiner and al (2013). Turn volatile commodity prices to your advantage. Oliver Wyman Insights

- **Stranded Asset:** These are assets that experience an unexpected demise, significant depreciation, or transformation into liability due to a set of risks associated with the environment. For example, the energy sector and particularly the oil and gas industry has recently suffered from a sharp drop in demand, which can be explained by the emergence of transition risks. Work on stranded assets has generally focused on non-renewable energy industries, but the problem is much broader.
- **Adjustment or relocation of activities:** Disruptions in the production of a product or in the process of commercial activity, leads to a relocation or adjustment of the activity. Factors in a decision to relocate or adjust the activity may include:
 - Cost change
 - Decrease in demand
 - Difficulties relating to hiring or retaining competent employees
 - Impacted productivity
 - Climatic changes, for example increase in severity or regularity of extreme climates
 - Litigation, where the business model or operations shift indefinitely as a result of liability risk manifesting.

in order to adapt, the adjustment or relocation of activities will lead to capital expenditure eg. international trade is changing due to new anti-deforestation regulations. Higher capital expenditures increase the financial risks associated with the business in the short to medium term.
- **Capital destruction:** The destruction of capital is manifested by physical risks which damage the enterprise, for example, floods which drown the stock of raw materials.

The six categories of transmission channel are defined below. They are economic impacts that can be acute and/or chronic:

Acute impacts are event-driven, with consequences that are sudden and often large, then recede until the event happens again.

Chronic impacts gradually worsen, with consequences that are not anticipated to recede or revert to their prior state.

The severity and regularity of these channels differs depending on the sector, geographic area, and company. The result is the same, greater exposure to nature related financial risks.

Equipped with knowledge about the physical, transition and liability risks related to nature loss, and the transmission channels that connect these risks with the financial world, it is possible to create a framework for identifying nature-related financial risks. Shown below, this framework begins with sources of nature-related financial risks (column A) and concludes with the financial risks (column D).



Figure 2 : Framework for identifying NRFR

Source: Handbook for Nature-related Financial Risks Key concepts and a framework for identification

This framework was initiated by the CISL(2021)¹⁰ to support financial institutions in their process of identifying and managing risks related to the environment. this tool is still under development and testing during the year 2021.

Its implementation will make it possible to anticipate the environmental risks relating to any sector. It does not provide a generalized model to measure this risk but identifies the risk factors of each sector.

¹⁰ University of Cambridge Institute for Sustainability Leadership, (2021). Handbook for Nature-related Financial Risks Key concepts and a framework for identification

CHAPTER 2– BIODIVERSITY RELATED RISKS

After having developed several tools over the past few years to quantify and manage climate risk, it is time to focus on biodiversity. International organizations came to an agreement in the Paris agreement which defines a global framework aimed at avoiding dangerous climate change by limiting global warming to a level well below 2 ° C and by continuing efforts to limit it to 1.5 ° C. It also aims to strengthen the capacity of countries to face the consequences of climate change and to support them in their efforts. This and other initiatives have enabled companies and financial institutions to measure their exposure to climate risks, the carbon footprint has been the measure most used in this direction. The management of climate risks does not include those linked to biodiversity, so how do you measure the biodiversity risk? several tools are still under development, we will present in this chapter several methods without going into details. And in the next section, we develop the methodologies that we consider relevant.

Before presenting methodologies, we should understand why we need to assess biodiversity risk, and we should stop funding business that harm biodiversity.

If we look at the following figure, it represents scenarios that could happen during the next 30 years, if we don't reverse the trend, we are putting the natural capital at risk.

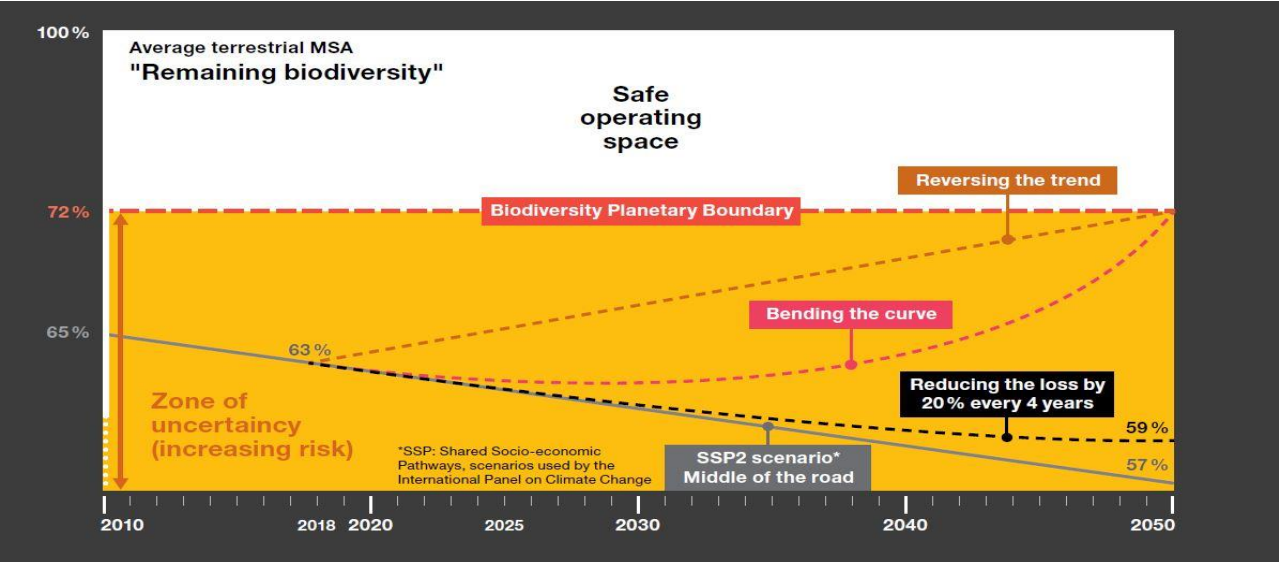


Figure 3: Scenarios to return to biosphere integrity.

Source: PWC (2020): Nature is too big to fail

MSA: The Mean Species Abundance of original species relative to undisturbed situations (MSA) is a metric that measures the level of “integrity” or “naturalness” of ecosystems.

We will explain this metric with more details when explaining the global biodiversity score.

IV. BIODIVERSITY RELATED RISKS ASSESSMENT

An investor wishing to manage the financial risks linked to biodiversity can follow several approaches. The dimensions he can consider:

- Corporate vs. portfolio/financial instrument vs. individual investee level
- Direct vs. indirect impact
- Impact caused by biodiversity loss (dependency) vs. impact causing biodiversity decrease
- Risks related to transactions connected to investments promoting biodiversity

One way to integrate the biodiversity related risk is developed by Natural capital protocol.

Natural capital protocol

A rapid assessment of the financial risks associated with biodiversity enables investors to identify the main areas of biodiversity risk to which the companies in which they hold shares are exposed. This assessment identifies how companies depend on the environment and what their impacts are. These impacts and dependencies can create previously unseen risks for financiers.

A general way of integrating the risk of biodiversity into investment decisions is to apply the methodology of Natural capital, it is composed of four steps and developed by the Natural Capital Finance Alliance and Global Canopy. financial institutions can set it up by adjusting it according to their needs.

The following table summarizes the main steps.

Step	Description
Frame : Why?	why do we need to assess this risk?
Scope : What?	Define objective and scope of the assessment Measure the impact and/or dependencies
Measure and Value: How?	Determine the impact drivers and/or dependencies Measure changes in the state of natural capital Value impact and/or dependencies
Apply: What next?	Interpret and test the results Take action

Table 2: Natural Capital Protocol Steps

Source: Natural Capital Coalition, Connecting Finance and Natural Capital – A supplement to the Natural Capital Protocol (2018)

Frame

Before setting up methods for calculating and managing financial risks related to biodiversity, we must first get acquainted with the main concepts, knowing the concepts related to nature and natural risks is extremely important in order to ensure a perennial risk assessment.

What is natural capital?

According to NCFCA Natural Capital “is a way of thinking about nature as a stock that provides a flow of benefits to people and the economy.

It consists of natural capital assets—such as water, forests, and clean air—that together provide humans the means for healthy lives and enable economic activity.”

Natural capital provides ecosystem services, these are the goods and services provided by nature, for example food and fiber, water, protection against risks and absorption of pollution.

Ecosystem services are fundamental for human life on earth, and therefore for many economic activities. Any degradation of natural capital represents a major risk for the activities that depend on it.

The economic activities most dependent on ecosystem services are the most exposed to natural risks, the following figure shows the link with financial institutions.

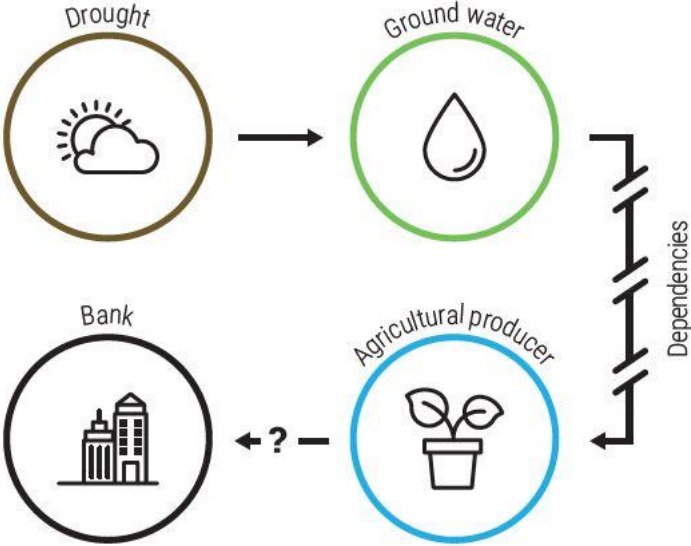


Figure 4 : Example of disruption risk potentially affecting a financial institution

Source: NCFR Phase 2 Report 2020

Financial institutions are exposed to natural capital risks that affect the businesses that they lend to, insure or invest in. If a bank is lending to a farm that is unable to sustain production or facing increased costs due to water shortages, or whose crop is failing regularly due to changing climate conditions, then the farmer may not be able to service loan payments temporarily or may go out of business in the long term.

✚ Scope

In this step, it is first necessary to control the risk management process already in place, to check whether it takes environmental risks into account. This makes it possible to assess the companies' capacities to predict and manage the risks associated with their activity.

The risk management process is verified at all stages: identification, assessment, etc. Then, it is important to take an inventory of all the risks and to classify them.

The creation of an inventory of all the risks of the company and their classification is not a simple task to do and sometimes takes a lot of time.

Therefore, the mapping should be fit-for-purpose and may be accelerated, especially if the assessment sponsor is already familiar with processes in place or is constrained in the time or resources available to conduct the assessment.

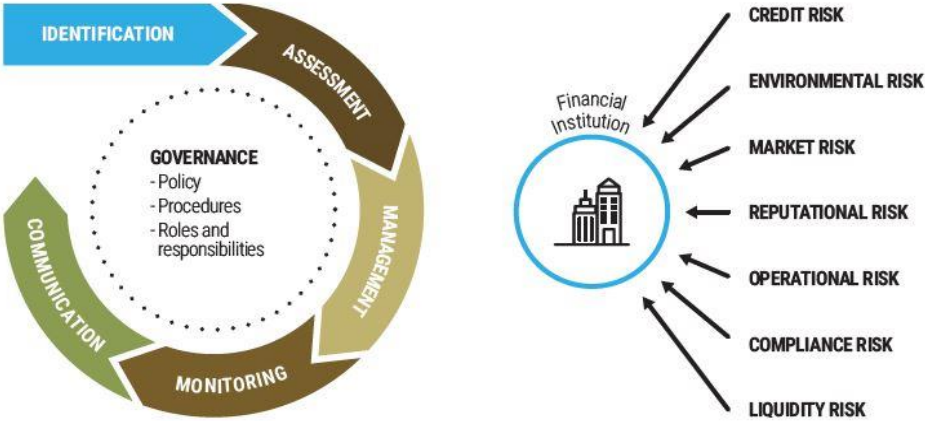


Figure 5: Stages of the risk management lifecycle and types of risks faced by financial institutions.

Source: Natural Capital Coalition, Connecting Finance and Natural Capital – A supplement to the Natural Capital Protocol (2018)

After evaluating the risk management process within the bank, after mapping the risks by carrying out an exhaustive inventory of risks, and after discussions with stakeholders, the risk manager can now set well-defined objectives, such as:

- identifying which natural capital risks are most material to the bank’s investment/loan portfolio in country [X] now and in the future.
- understanding the current state of these risks and how these are likely to evolve.
- identifying information needed to make decisions and manage natural capital risk exposure.

This will lead us to the definition of the scope, the bank must consider two key aspects for the definition of the scope: the geographic borders which represent the level of analysis and focus of the assessment which means lens of analysis. Both aspects must be taken into account in parallel to be sure that the scope complies with the resources and time allocated.

The bank first chooses a geographic scope, which must necessarily be in accordance with the resources, timescale, priorities, and appetite for granularity. The bank will then determine the lens of the analysis, which it wants to use in order to capture the risk of its portfolio. The choice of this lens determines how the information relating to natural capital will be analyzed. Here we present two possible lenses: sector and natural capital consideration.

Firstly, the bank can take a sectoral lens to conduct its assessment, the sector analysis has an advantage, it is the fact that the stakeholders are familiar with this method, the bank can also choose to deepen its analysis towards the sub-sectors, on which it depends, this will allow banks to refine the assessment and thus the conclusions will be more relevant.

To filter the sectors or sub-sectors to be studied, there is a simple approach consisting in choosing 5 or 10 sectors per portfolio value, there are also other criteria to limit the number of sectors:

- a) Sectors at higher risk of default
- b) Sectors with multiple material dependencies on natural capital, such as primary sectors, energy, utilities and mining
- c) Sectors for which environmental risk management is particularly lacking within the bank’s current processes
- d) Sectors to which the bank is considering lending for the first time

The following figure summarizes the steps that the bank should follow before defining its assessment scope.

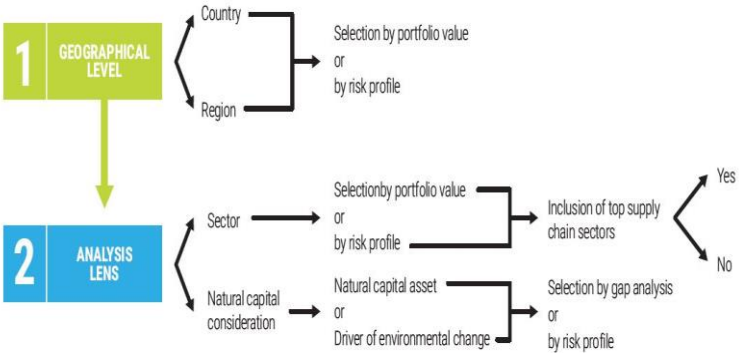


Figure 6: steps for defining the scope of the assessment.

Source: NCFA Phase 2 Report 2020

After having defined the scope of the assessment, we should now move on to the next step which consists of assessing.

Assess

For each sector or production process selected, ENCORE is the tool that provides the ecosystem services essential to each sector or sub-sector and the drivers of environmental change that influence them.

Risks of disruption of nature depend on the capacity of natural capital to provide normal ecosystem services on which depend economic activities. The bank must therefore understand the state of these natural assets which are essential for the activities in which it invests and assess the risks to which it is exposed. The bank can easily identify the natural capital assets on which any sector (or production process) depends by selecting the sector in ENCORE's drop-down menu. It can then use the 'natural capital assets' page of the tool to explore the various assets that deliver the key ecosystem services on which the sector depends.

Identifying the drivers of environmental change is an essential step in the assessment of natural risks, because these drivers impact several natural assets and ecosystem services, ENCORE can also be used to identify these drivers.

Sectors and sub-sectors generally have several drivers of change in nature that impact them directly or indirectly, the bank can therefore choose which ones to focus on.

Options for doing so include:

- Focusing on drivers of environmental change that have a high influence on the production processes included in the assessment's scope - this information can be found in the ENCORE tool;

- Conducting background research to understand drivers of environmental change that are likely to be problematic in the geographies in scope;

- Habitat modification and weather conditions are drivers of environmental change that have a significant influence on many sectors of the economy and in many different geographies across the world. Limiting the analysis to these two drivers of environmental change will not lead to exhaustive findings as in some instances other drivers may be equally or more relevant to a bank's portfolio. Nevertheless, it can be a good starting point for those conducting a rapid natural capital risk assessment for the first time.

After having identified the natural assets essential for economic activity, as well as the drivers of environmental changes, it is possible to assess the natural risk and even identify the geographical areas most vulnerable to changes in nature. ENCORE includes the geographical function, which allows to visualize on a map the data relating to a driver of the change of environment, the bank can therefore adjust its portfolios present in different geographical areas.

What will happen after assessing nature related financial risk?

Apply

When the risk assessment is successfully carried out, the results should be aggregated and reviewed in order to understand the implications for the bank's portfolio, this will be adjusted according to these risks, for example less capital allocation for a sector very dependent on ecosystem services.

Communication and synthesis of results must be done in such a way that it is understood by all stakeholders, there are several ways to analyze them, including identifying the sectors and geographic areas most at risk, or finding the drivers of environmental change that have the most severe impact on nature and that disrupt nature now or may do so in the future.

There are examples of how to communicate results and action plan to key stakeholders:

Communicate to them the level of the risks, for example communicate to them the portfolios composed mainly of loans exposed to regions where the natural risk is high.

providing clear recommendations for better risk management e.g. regions/sectors which should be monitored more closely in the future,

In addition to this information, it is important to communicate to them the assessment methodology, the data collection, but also any material information must be shared. This allows them to increase confidence, but also to clearly communicate the assessment's limitations.

There exists another approach to assess biodiversity related risk developed by ACTIAM, ASN Bank and CDC Biodiversité¹¹ which focuses on the assessment of investment (or loan) impact on biodiversity in four steps.

Biodiversity foot-print approach

This approach is composed of four steps that we develop in this part:

Step 1) Analysis of the focus of the investment

The first thing that we should do is to analyze the investee and its most important activities which depend on biodiversity, to do so there exist 4 different scopes on analysis:

Scope 0: this is a static footprint which is independent of activities of investee, it is also called the spatial footprint of existing facilities.

Scope1: Impacts on biodiversity resulting directly from activities controlled by investee.

Scope2: Harms caused by the consumption of energy (for example electricity).

Scope3: footprint caused by upstream and downstream consequences of the investee's activities but not under its immediate control, such as third-party supply chain.

An important aspect of this process is the definition of the attribution of the impact to the respective stakeholder based on chosen factors, such as financial or operation control or affiliated companies.

Step 2) Assessment of the pressures on biodiversity

The second stage of this approach consists to assess the pressure on biodiversity causes by economic activities, this step can be based on data provided by investee or external databases. In this step, it is important to evaluate the footprint's relevancy, the transparency, compatibility, robustness and consistency of the data and methodology used.

Step 3) Assessment of the impact on biodiversity

The next step is to transform the pressure data into economic data in order to be able to analyze them correctly and draw conclusions.

¹¹ ACTIAM, ASN Bank, CDC Biodiversité (2018). Common ground in biodiversity footprint methodologies for the financial sector.

Step 4) Interpretation of the footprint results

The last stage concludes the process with an interpretation of the results and focuses on a supplementing qualitative analysis and addresses the limitations.

At each of these four stages, we have a tool that allows us to perform data transformation. And these steps correspond to those of the GBS which we will explain in detail in the last part of this section.

After having presented the main methodologies used to measure the financial risk linked to nature, we will therefore identify how they are different from ESG scoring, or in other words what are the contributions of these methodologies compared to ESG.

V. Beyond ESG Scoring

Environmental, Social and Governance (ESG) criteria are the three main dimensions used to measure the sustainability and the ethical impact of an investment in a company or in an economic area. These are the three main elements that make up this responsible investment. The methodology used to give a score to each of these three criteria differs depending on the company you want to evaluate and its sector, but also depends on the rating agency. We focus on the scoring of the environmental criterion, in order to compare it with other methodologies.

ESG is above all a criterion of sustainable and ethical investment, it is based on the past data of the company. Sometimes the only data available is that given by the company to the rating agency. their accuracy is still in question.

Regarding the issue of the environment, it is complex to measure the environmental risk, because it is necessary to take into account dependencies as well as the impact of the activity on nature.

To show the need for another environmental risk measurement other than the ESG environmental criterion score, we will show the example of the methodology used by MSCI which provides ESG scores for thousands of companies.

In the following table, we have summarized the factors taken into account by the MSCI scoring to assess the environmental risk.

Environmental criterion

Issue	Average Weight
Carbon Emissions	
Product Carbon Footprint	
Climate Change	
Vulnerability	
Water Stress	
Biodiversity & Land Use	
Raw Material Sourcing	
Financing Environmental Impact	
Toxic Emissions & Waste	
Packaging Material & Waste	
Electronic Waste	
Opportunities in Clean Tech	
Opportunities in Green Building	
Opportunities in Renewable Energy	

Table 3: Environmental factors of MSCI ESG Scoring

Source : <https://www.msci.com/our-solutions/esg-investing/esg-ratings/materiality-map>

Each of these factors is assigned a weight, depending on the sector, the subsector, the country ... This approach is similar to that used by ENCORE, except that the MSCI is limited to the impact of the company on these different factors, while the risk comes mainly from the dependence of the activity of the company on natural changes, it is good to identify the impact on nature in a purely ethical approach, but not enough to understand the relationship that can exist between a vector of natural change and an economic activity.

The correlation between an ecosystem service and any economic activity is not captured by the score, knowing that this relationship is the main measure in the identification of risks.

Based on the MSCI methodology, a company that is "friendly" to the environment - for example, its CO₂ emission is minimal - will have a better score, even if this company depends in its activity directly or indirectly on several ecosystem services, and therefore exposed to environmental risks, these risks are therefore not included in the ESG score. The main risks that we have already identified are the physical risk, the transition risk and the liability risk. The ESG score based on the factors in table 3 lists the impacts of the activity and does not give a vision not only on dependencies on nature - which constitute the physical risk - but also on the risks of transition and liability. These risks are costly, and the potential financial losses are enormous.

Another limitation of the ESG is the fact that it is done annually, while environmental risks can occur in the short term, so it is better to know in advance the dependencies of an activity on nature before investing in it in order to integrate this risk into the cost of capital.

We know that ESG is the methodology most used today for responsible investment, other tools that have just been operational or that are still being developed will be complementary to ESG with regard to environmental risks in order to quantify all non-financial risks. In the section devoted to methodology, we will present the most recent NRFR measurement tools.

The literature review interested in NRFR is still limited to generalities relating to the interactions between financial system and nature. The majority of writings belong to financial organizations, consulting firms ... academic articles that deal with related issues are very few.

In the first chapter, we studied the interaction between finance and nature, the resulting financial risks, their sources and their transmission channels. The second chapter was devoted to the risks linked to biodiversity and the methodologies that exist to assess them.

The question of measuring the environmental risks raises many other questions for finance professionals. The most important question is to know whether the market already integrates these risks? which method is the most suitable for evaluating them? what impacts will these measures have on the risk-return framework? In the following section, we will detail each of these questions, then in the methodology part we will develop the methodologies and tools that can be used to answer these questions.

PART 2

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RESEARCH PROBLEM AND METHODOLOGY

RESEARCH PROBLEM

The question of our thesis consists in developing a feasible method to assess the financial risks linked to the environment. Answering the question "how to measure NRFR" raises several other problems, the study of which is essential to choose the most robust method to measure this risk. One of the obvious questions to which we have already provided some answers is to say: why not just use the ESG score and look at the environmental factor score and consider it as a measure of environmental risk? we have shown that the ESG focuses on socially responsible investment, and therefore the environmental score is based on the company's impact on the environment rather than on the dependence which is the source of the risk.

Other questions are also important, to define the assumptions, a fundamental question is whether the market has already incorporated NRFR into investment decisions.

To check if the market has integrated this risk, it is important to study the return, there is a moment of awareness when investors identify environmental risks, and automatically they will ask for additional return to compensate for their exposure to these risks. If we manage to make a link between this additional return and the environmental risks, we can affirm that the market takes these risks into account, and we can then study the environmental risk premium. What is the moment that can be considered as a moment of awareness? the moment that seems decisive to us is the moment when the risk measurement tools are available. Currently the two most famous tools (which we will present) are ENCORE and GBS and are not widely available. The answer to this question will therefore have to wait until these tools are better known or the development of other tools.

why do we want to know if the NRFR are already integrated into the stock market price? the answer to this question will allow us to develop the appropriate methodology. If we manage to demonstrate that they are taken into account by the market, an adequate methodology to measure these risks is to use a "market approach", that said the analysis of the sensitivity of the price to the risk factors, we will detail this methodology in the next part. If, on the contrary, the market does not send a signal or it is weak, it is more relevant to

develop other approaches based on other measures other than the return since the latter does not reflect this risk.

After having checked whether the risks are already integrated by the market, comes the study of the impact of these risks on investors' portfolios and investment strategies. We know that the more the risk increases, the more the required return increases to compensate the risk exposure, and therefore the evaluation of this risk will impact the risk-return framework. Here we have two things to study, on the one hand the level of risk and on the other hand the expected return.

First, it is known that globally the companies with the best ESG score have the lowest classical risk measurements (Volatility) (OECD 2020)¹². is this the case for companies with the lowest environmental risk? does the volatility reflect this risk for example?

Then, with regard to the expected return of the portfolio, what changes will be made in relation to the capital allocation? will the overall performance of the portfolio improve by integrating companies with a higher environmental risk? The sharp ratio is a measurement which allow us to compare the performance of several portfolios and to confirm or not this hypothesis using statistical tests.

What financial instruments can be developed to hedge against these risks? what future for green derivatives?

The research question raises several questions, we bring some thoughts about the subject, but unfortunately, we cannot empirically test our hypotheses.

METHODOLOGY

Before presenting the methodologies that we have been able to develop, we will first present two very recent tools that we find very useful in our approach. These two tools are : ENCORE and GBS.

❖ ENCORE

Exploring Natural Capital Opportunities, Risks and Exposure (ENCORE) was developed by the Natural Capital Finance Alliance¹³ in partnership with UNEP WCMC to help users

¹² OECD (2020): ESG investing: practices, progress and challenges

¹³The NCF is a global alliance of financial institutions pioneering tools and best practice to manage natural capital risks and opportunities.

better understand and visualize the impact of environmental change on the economy. The tool relies on a mix of data sources, literature reviews, sector reviews as well as expert interviews to create a comprehensive picture of the interaction between 86 production processes and 21 ecosystem services, classified based on the Common International Classification of Ecosystem Services (CICES). It covers 11 sectors and 167 subindustries classified according to the Global Industry Classification Standard (GICS).

ENCORE provides a list of the ecosystem services each production process depends upon, the natural capital assets that produce these and the drivers of environmental change that influence their provision. The tool assigns materiality ratings by considering the degree of disruption to production processes that would be caused by the loss of ecosystem functionality and its associated impact on company profits. A 'very high' materiality rating suggests that the loss of functionality prevents the production process from continuing which endangers the financial viability of the company.

The ENCORE tool gives, for each sector or sub-sector, the ecosystem services on which they depend, the vectors of environmental changes by geographic area. This allows investors to adjust their portfolios according to these zones.

The real added value of ENCORE is that it is not only interested on the impact of activities on environment, but also the dependence of this activity on an ecosystem service. its database composed of 11 sectors and 167 sub-sectors really helps investors wanting to diversify their portfolios and can therefore set up investment strategies based on the data provided by ENCORE.

The limitation of this tool is that it is based on sectoral data. In wanting to buy a certain number of stocks of a company, an investor will not limit himself to sectoral averages to assess the risk but will want to analyze the risk of this particular company.

❖ GBS

The Global Biodiversity Score (GBS) is a corporate biodiversity footprint assessment tool which focuses on the biodiversity impacts of economic activities across their value chain, in a robust and synthetic way.

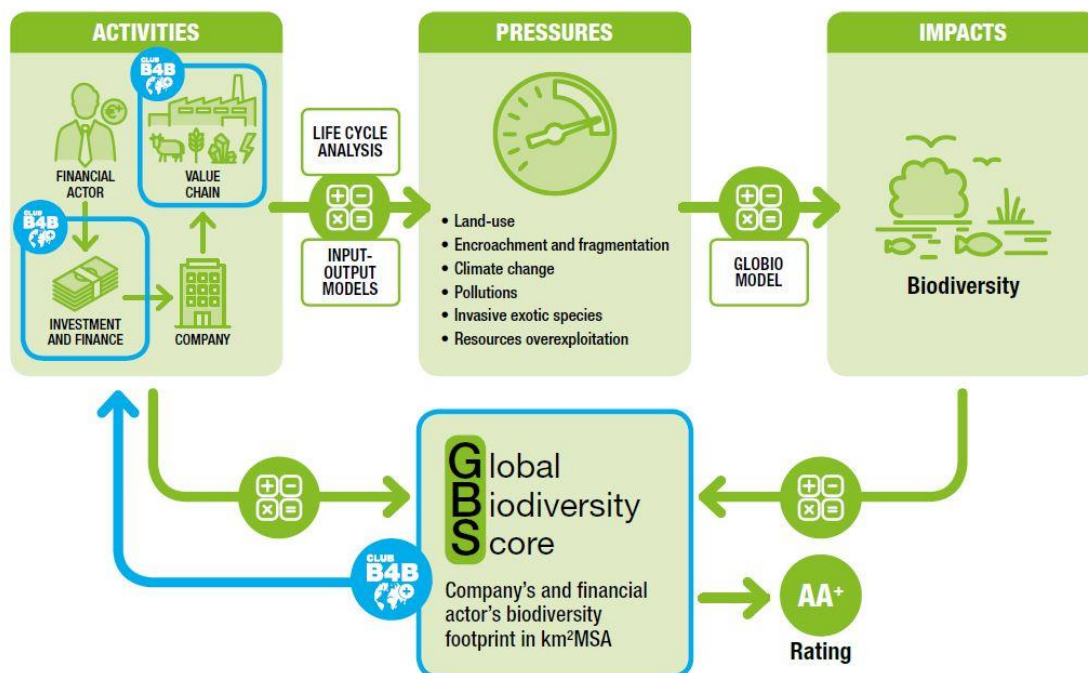
It is developed with the support of about 30 businesses and financial institutions gathered in the Business for Positive Biodiversity Club (B4B+ Club) and through collaborations with academics, NGOs and other corporate biodiversity footprint initiatives.

After three years of development, a first version of this tool was officially launched on May 12, 2020. Today it is being updated for a future improved version.

The principle of the Global Biodiversity Score

Calculating the biodiversity footprint of a company or a financial actor via the GBS consists to establishing a quantitative link between its activity and impacts on biodiversity.

This can be calculated in three steps. The first step is to make the link between the economic activity of the company and the pressures affecting biodiversity, that is to say to quantitatively analyze the contribution of the economic activity of the company to these pressures. The second step is to analyze the impact of these pressures on biodiversity and in the last step, we analyze the impact of changes on biodiversity on economic activities of the



company.

Figure 7: Steps of the GBS

Source: CDC Biodiversité(report 2020)

The final result expressed in km²MSA, or "Mean Species Abundance", a metric created by the PBL (Dutch environment institute) and used by the United Nations (IPBES), the Convention for Biological Diversity, it is endowed with the qualities required for an impact indicator, and connects the major pressures to an equivalent area of destroyed biodiversity.

How to calculate MSA:

$$\text{MSA}(\%) = \frac{\text{observed biodiversity (species)}}{\text{undisturbed biodiversity (species)}}$$

Example

2 rules to calculate MSA:

- We don't account species present only in the disturbed situation.
- We don't account increase in abundance.

1 km²MSA loss is equivalent to a destruction of 1 km² of pristine natural areas.

The Mean Species Abundance (MSA) metric

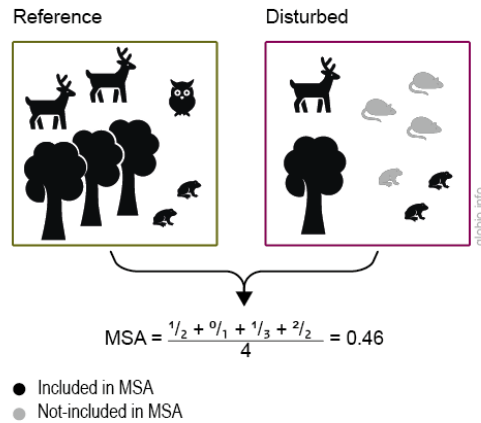


Figure 7 : MSA calculation

Source: CDC Biodiversité (report 2020)

To assess the biodiversity related risk, the most known two tools already developed are ENCORE and GBS, therefore consequently, the methodologies that we propose depend on these two tools. The first one manages the NRFR at a sector level and country level, the second one focuses on the company level by analyzing biodiversity score provided by CDC Biodiversité.

The objective of these tools is to use them to set up relevant methodologies to assess the financial risks linked to the environment, we already have two methodologies, one is sectorial, and the other is specific for each company.

1) Sector level

To assess how far economic sectors depend on Biodiversity, we can use the online tool: Exploring Natural Capital Opportunities, Risks and Exposure (ENCORE). We convert the materiality rankings done by ENCORE, evaluating the dependency of production processes on different ecosystem services on a scale of 1–5, with 1 representing very low materiality (limited loss of functionality and financial impacts) and 5 representing very high materiality (severe loss of functionality and financial impacts).

Knowing the sectoral dependency on Biodiversity and the different value contributions of these sectors to the GDP allows us a new view, assuming that higher dependency ultimately leads to higher risks. We multiply the percentage of the GDP contribution of an economic sector by the biodiversity dependency ranking of that sector, this gives us a new ranking by countries, and then financial institutions can manage their activities across countries (lending, investment, re/insurance) by considering this risk.

This method is global, it is useful for a sectorial or macroeconomic analysis, but it is not sufficient for a risk management specific to each company. To solve this problem, we thought of another much more precise and sophisticated method.

2) Company level

This methodology is more precise and more difficult to realize due to lack of Data, we will explain how we think it can help to assess the biodiversity related risk.

By supposing that the market has already integrated biodiversity risk, and that we have significant sample of firms which biodiversity scores are provided by GBS for example, we can add a new risk factor as it is the case for the Carbon risk in Carima(Carbon risk management) project, developed by Gorgen et al. (2019)¹⁴. The objective of the carbon risk management (Carima) project, developed by Gorgen et al. (2019), is to develop “a quantitative tool in order to assess the opportunities of profits and the risks of losses that occur from the transition process”. Theo Roncalli(2021)¹⁵.

The market approach of Carima consists in building a brown minus green or BMG carbon risk factor, and computing the risk sensitivity of stock prices with respect to this BMG factor. We are following the same approach except that we are focusing on biodiversity rather than carbon risk.

¹⁴ Gorgen and al(2019), Carbon risk management (CARIMA) project, University of Augsburg, Queen's University.

¹⁵ Roncalli (2021): Master in Bioinformatics & Biostatistics University Paris-Saclay.

The construction of the HMF (Hostile Minus Friendly) factor follows the methodology of Fama and French (1992)¹⁶, which consists in splitting the stocks into six portfolios: small friendly (SF), small neutral (SN), small hostile (SH), big friendly (BF), big neutral (BN) and big hostile (BH). Then, the return of the HMF factor is dened as follows:

$$R_{hmf}(t) = \frac{1}{2}(R_{SH}(t) + R_{BH}(t)) - \frac{1}{2}(R_{SF}(t) + R_{BF}(t))$$

Let $R_i(t)$ be the monthly return of stock i at time t . We assume that:

$$R_i(t) = \alpha_i(t) + \beta_{mkt,i}(t)R_{mkt}(t) + \beta_{hmf,i}(t)R_{hmf}(t) + \epsilon_i(t)$$

Where:

$R_{mkt}(t)$ is the return of the market risk factor,

$R_{hmf}(t)$ is the return of the HMF factor

$\beta_{mkt,i}$ is Beta of market factor, it is calculated as $\text{cov}(R_{mkt}, R_i) / \text{Var}(R_{mkt})$

$\beta_{hmf,i}$ is Beta of HMF factor,

and

$\epsilon_i(t) \sim N(0; \sigma_{2i})$ is a white noise.

We can add these factors to the Fama French model to estimate returns.

We have then to compute the biodiversity beta, as in the case for carbon beta, we can use a dynamic approach by assuming that the betas are time varying. This is more realistic since carbon betas may evolve with the introduction of a biodiversity-related policy, a firm's environmental controversies, a change in the firm's environmental strategy...

These two methodologies are complementary, and their objective is to assess the financial risk linked to nature, this being the objective of this thesis. we have presented the model which seems relevant to us, we were not able to carry out empirical tests. Our model is based on GBS data, which is currently not available.

¹⁶ Fama, Eugene F, French Kenneth R. (June 1992): The Cross-Section of Expected Stock Returns, The journal of American Finance Association.

CONCLUSION

The main research question of our thesis is to present a relevant method for the assessment of financial risks linked to the environment. These risks can be specific to each company as they can have a systemic dimension. The macroeconomic aspect of these risks is characterized by the complexity and the randomness associated with the environment. Our thesis focused on specific risks, ie the dependence and impact of a company's economic activity on the environment, which translates into financial risks. The interdependence between economy, finance and nature favors the realization of these risks, which manifest economically in the form of shocks of demand and supply. The sources of financial risk are physical risk, transition risk and liability risk.

With the aim of preserving the environment and promoting socially responsible investments, several changes have taken place in the international financial sphere, we mention the ESG, the carbon footprint ... we notice that they do not take an account sufficiently a primordial aspect of nature, it is about biodiversity. We have therefore presented the literature that focuses on these risks, and the methodologies developed to assess them especially the Natural capital protocol approach and the biodiversity footprint. This allowed us to have a global vision on several aspects of the problem and to arise other fundamental questions. Why don't we just use ESG scoring? What are the contributions of our methodology? what is the impact of risk measurement on portfolios? these questions and others define our hypotheses and allow us to choose the most appropriate methodology.

Before presenting the methodologies that we have been able to develop, it is important to present two very recent tools that we find very useful in our approach. These two tools are: ENCORE and GBS.

The methodologies that we propose are based on these two tools and are complementary, since one is dedicated to the sectors, according to the geographical areas using data from ENCORE, and the other is much more precise and is based on biodiversity scores provided by GBS.

Combining these two methodologies will allow investors to measure the financial risks linked to nature, to set up investment strategies and to adjust capital allocations according to these risks.

The main limitation of our work is the fact that we did not do statistical tests to verify our hypotheses. The lack also of academic articles which deal with similar themes is a limit of our memory, since the majority of the literary review is made up of reports published by financial institutions and consulting firms. The methodologies proposed are based on data from ENCORE and GBS, these are very recent tools, we cannot confirm the relevance of these data.

The subject of our research remains a very recent subject, the recent conferences linking the scientific community, professionals, and regulators aim to develop relevant tools and methodologies to measure and manage these risks. this expresses the importance of the subject for economic and financial actors. it's still a fairly new topic and there are still a lot of themes worth exploring.

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ABBREVIATIONS

CISL: Cambridge Institute for Sustainability Leadership

ENCORE: Exploring Natural Capital Opportunities, Risks and Exposure

FIs: financial institutions

GBS: Global Biodiversity Score

NCFA: Natural Capital Finance Alliance

NRFR: Nature Related Financial Risk

REIT: Real Estate Investment Trusts

TCFD: Taskforce for Climate-Related Financial Disclosures

TNFD: Taskforce for Nature-Related Financial Disclosures

WEF: World Economic Forum

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