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Course of Green and Sustainable Finance

The impact on the financial risk of banks resulting from the loss of biodiversity and ecosystems

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1. INTRODUCTION

The introduction will discuss the topic's historical context, which led to the knowledge gap that this research seeks to address. The study questions, scope, and limits are then discussed.

1.1. BACKGROUND AND RELEVANCE

Ecosystem services are typically defined as the benefits humans receive from ecosystems (Boyd & Banzhaf, 2007; Costanza et al., 1997; Daily et al., 1997; Millennium Ecosystem Assessment, 2005; Fisher et al., 2009; TEEB, 2012; Costanza et al., 2017) and are categorized into four categories: provisioning, regulating, cultural, and supporting ecosystem services. Examples of each are timber and fish (provisioning), pollination (regulating), tourism-related coral reefs (cultural), and nutrient cycles (supporting) (Millennium Ecosystem Assessment, 2005; FAO, 2021b, 2021c, 2021d, 2021a). Ecosystem services are dependent on biodiversity and are thus closely related (Cambridge Conservation Initiative, 2020; De Nederlandsche Bank, 2020a; Hanson et al., 2012; United Nations, 1992; UNPRI, 2020; WWF, 2020). Therefore, this thesis utilizes the terms biodiversity and ecosystem services (BES) interchangeably. Businesses can benefit from ecosystem services through the facilitation of operations (such as crop pollination and predator and parasite control in ecosystems), the supply of raw materials (such as timber, wool, food, freshwater, and medicinal resources), water purification, and cultural services (such as contributions to education and tourism) (Millennium Ecosystem Assessment, 2005; FAO, 2021a, 2021b, 2021c, 2021d). Although it is difficult to quantify the value of ecosystem services (Newton et al., 2018), several studies have broken down the monetary values given by ecosystem services for various goods or industrial sectors. Examples include forest products such as timber and paper, which account for USD 247 billion of global trade exports (FAOSTAT-Forestry database, 2017); the pharmaceutical sector, where 25-50% of products are based on genetic compounds derived from nature (IPBES, 2019); the value of the global fishery sector, which is estimated to be worth USD 362 billion (FAO, 2018) or the value of soil biodiversity which is estimated to lie between USD 1.5 trillion to 13 trillion (Data European Soil Centre, 2021). According to Costanza et al., the yearly value of ecosystem services is between USD 125 trillion and

USD 140 trillion (Costanza et al., 2014). Regarding inherent uncertainties, the study provides compelling evidence that people place a high monetary value on ecological services. Constanza's 2014 estimates are comparable to a recent OECD report from 2019 and equal to 1.5 times the world GDP (OECD, 2019). More than half of the world's gross domestic product (USD 44 trillion) is moderately or strongly dependent on ecosystem services and natural capital assets, according to a World Economic Forum report (World Economic Forum, 2020b). However, at the risk of oversimplification, the continuous unsustainable economic expansion (both production and consumption patterns) of mankind, which is exacerbated by climate change, is causing the productivity of ecosystem services to decrease (Costanza & Daly, 1992; Millennium Ecosystem Assessment, 2005; Dasgupta, 2008; UNEP, 2016; Maxwell et al., 2016; van der Geest et al., 2019). While the global economy flourished between 1992 and 2014, as evidenced by a doubling of produced capital per person and a 13% growth in capital per person, studies indicate that the stock of natural capital per person has declined by 40% (Dasgupta et al., 2021). In 2005, the Millennium Ecosystem Assessment indicated that around sixty per cent of the twenty-four analyzed ecosystem services are deteriorated, whereas the only ones that have improved are directly related to our emphasis on food production, such as cattle or aquaculture (Millennium Ecosystem Assessment, 2005). And according to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), by 2019 humans would have changed 75% of the earth's land surface, destroyed 85% of all wetland habitats, and degraded more than 85% of the ocean (IPBES, 2019). Studies indicate that unsustainable economic expansion is not just exceedingly perilous for the vast majority of non-human life on earth, but that its influence on ecosystem services will also have serious consequences for our way of life, particularly our economy (TEEB, 2010). In their study, Costanza et al. (2014) projected that between 1997 and 2011, biodiversity loss and ecosystem degradation cost the world economy between USD 4.3 trillion and USD 20.2 trillion (Costanza et al., 2014). If a business-as-usual scenario leads to a reduction in the supply of six ecosystem services (pollination of crops, protection of coasts from flooding and erosion, supply of water, timber production, marine fisheries, and carbon storage), the global GDP could decline by 0.67 per cent per year until 2050 (Roxburgh et al., 2020). In terms of specific ecosystem services, examples include:

pollinator loss puts USD 400 billion of global crop output at risk, overexploitation of fishing grounds costs USD 50 billion annually (IPBES, 2019), and land degradation can have significant effects on the ecosystem service value (ESV) of many nations (Kertész, 2017). China is anticipated to lose 6.6% of ESVs annually, Russia 7.4%, the United States 8%, and India 20.3%. (Sutton et al., 2016). Globally, land degradation has lowered the ESV by USD 6,3 trillion per year (Sutton et al., 2016). Furthermore, land deterioration is not the sole threat. For instance, the World Economic Forum identifies biodiversity loss and its effect on ecosystem service as one of the most consequential and probable global hazards for 2020 (World Economic Forum, 2020a). This extinction has a negative influence on the advantages that humans derive from ecosystems (Cardinale et al., 2012; Hooper et al., 2012). As the negative effects of ecological degradation and the resulting economic repercussions increase, it is reasonable to inquire about the implications for financial institutions such as banks. In the European Union, financial institutions are classified as monetary financial institutions, investment funds, financial vehicle corporations, institutions related to payment statistics, insurance corporations, and pension funds (European Central Bank, 2021c). In this definition, credit institutions (used as a synonym for banks) (De Nederlandsche Bank, 2021), which are monetary financial institutions, are described as "an enterprise whose business is to accept deposits or other repayable money from the general public and provide credits for its account" (European Banking Authority, 2019, 2020). In other words, one of the fundamental activities of banks is characterized as the supply of finance and lending solutions to the company (Allen et al., 2014). If ecosystems are degraded and firms are exposed to dangers, then financial institutions such as banks may also be harmed (OECD, 2019). This thesis will concentrate on banks to illustrate a significant subset of financial entities.

The primary threats to biodiversity and ecosystem services (BES) faced by financial institutions are physical and transitional (Cambridge Centre for Sustainable Finance, 2016; G20 Green Finance Study Group, 2017; NGFS, 2020). These two environmental risks can then result in the following financial risks: (i) credit risk (default of credit), (ii) market risk (declining value of assets), (iii) underwriting risk (increasing insurance gap and increasing insurer losses), (iv) operational risk (disruptions to the supply chain or other operations), and (v) liquidity risk (increasing demand for capital) (Cambridge

Centre for Sustainable Finance, 2016; G20 Green Finance Study Group, 2017; NGFS, 2020). As seen by the development of efforts such as the Network of Central Banks and Supervisors for Greening the Financial System (NGFS) and the Taskforce for Nature-related Financial Disclosure (TNFD), there has been a recent increase in awareness in the financial industry. The EU Taxonomy law outlines six environmental objectives for the EU policy agenda, one of which is "the conservation and restoration of biodiversity and ecosystems" (Regulation (EU) 2020/852, 2020). Lastly, financial institutions do independent research, such as the Dutch Central Bank, ASN Bank, and CDC Biodiversity. For instance, in the framework of this argument, equity investments of financial institutions in the Netherlands totalling EUR 510 billion are highly or very highly dependent on ecosystem services (De Nederlandsche Bank, 2020a). In 2019, the world's 50 largest banks are supporting enterprises that exacerbate climate and biodiversity issues, according to separate research (Portfolio Earth, 2020). However, these estimates may represent just a portion of the actual risk that exists. In 2018, the 6,088 credit institutions in Europe possess assets totalling 43.35 trillion euros (European Banking Federation, 2020a). And by the end of 2020, the 112 major banks monitored by the European Central Bank (ECB) would possess assets totalling EUR 24,1 trillion. This consisted of 5 trillion euros in loans to non-financial corporations and 2,9 trillion euros in debt securities, including equity holdings (European Central Bank, 2020a, 2021a). As financial institutions adhere to the basic "risk/return" ratio, a greater awareness of the true effect of environmental hazards and dependencies and the internalization of this information into the "risk/return" ratio might result in a shift in investments (Suttor-Sore, 2019). As a result, it is in the best interest of the financial industry and banks to include environmental risks effectively, as a lack of awareness of any risks can result in the accumulation of threats and the allocation of resources to higher-risk activities. Failure to do so might threaten the long-term stability of our economy (Cambridge Centre for Sustainable Finance, 2016). Financial institutions may play a crucial role in mitigating the global economic hazards of BES loss if they comprehend the dangers and act on them more aggressively than they do now (ShareAction, 2020; TEEB, 2010). Long-term neglect of environmental risks can lead to the emergence of systemic risks that wreak havoc on the financial sector and the broader economy (Monnin, 2018).

1.2 PURPOSE AND OBJECTIVES

This research seeks to investigate the impact of the financial risk posed by the loss of biodiversity and ecosystem services on banks.

Through a review of current literature, it was determined how the loss of biodiversity and ecosystems translates into a serious danger for the financial sector, with an emphasis on banks.

After investigating the aforementioned, it was determined how banks' approach to this type of risk is evolving, shifting from an approach based on the simple analysis and integration of risks arising from the loss of biodiversity and ecosystems to a step forward, encompassing the allocation of credit to promote and accelerate the green transition.

As a final component of the literature analysis, we investigated ways to assess the likelihood that biodiversity loss and the measures taken to fight it provide financial risks that undermine the stability of individual financial institutions and the financial system as a whole.

Following a review of the relevant literature, a case study approach was adopted to investigate current challenges and future priorities in the landscape of nature data in order to explore challenges, key issues, and potential opportunities for data development through the lens of the TNFD beta assessment process for nature-related risks and opportunities.

2. CONCEPTUAL FRAMEWORK

The conceptual framework summarizes the available literature on the study issue and groups it into three basic categories. The reader will first learn about the status of BES in the broader environmental context and the path that BES risks can go from being an environmental issue to a financial risk for banks. Second, the European banking industry is described in greater depth, with an emphasis on the (environmental) risk assessment of these institutions. Finally, a case study from the European financial sector

is provided that already take BES risks into account and hence provide intriguing conclusions for this study.

2.1 LINKAGE BETWEEN ECOSYSTEM SERVICES AND BANKS

To illustrate why banks should include ecosystem service reliance or effect into their risk assessment, it is necessary to comprehend what ecosystem services are and the dangers that companies and, by extension, banks face. As ecosystem service risks are a subset of environmental hazards and banks are a subset of the financial sector, and the line between these two categories can be ambiguous at times, it is possible to include additional research and conclusions by combining the two wider terms.

2.1.1 *Ecosystem services*

The roots of the phrase ecosystem services may be traced back to the late 1970s (Braat & de Groot, 2012), however it has been increasingly prevalent and well-described during the past two decades. In addition to varying terminology, the majority of definitions refer to ecosystem services as the benefits people receive from ecosystems, with the term "benefits" referring to the beneficial influence on our well-being (Boyd & Banzhaf, 2007; Costanza et al., 1997; Daily et al., 1997; Millennium Ecosystem Assessment, 2005; Fisher et al., 2009; TEEB, 2012; Costanza et al., 2017). It is essential to note that ecosystem services must always have an effect on human well-being; they cannot be explained without reference to humans. Ecosystem processes or ecosystem functions define non-human aspects of ecosystem work (Costanza et al., 2017). Past research in the field of ecosystem services has resulted in the establishment of its own journal (Braat & de Groot, 2012) and, more importantly, two UN led research groups that have published various research since their inception, the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2021) and The Economics of Ecosystem & Biodiversity (TEEB, 2021).

As ecosystem services are obtained from ecosystems and ecosystems are a component of biodiversity (which also includes the variety of organisms within species and across species, according to the United Nations (1992)), there is an obvious connection between ecosystem services and biodiversity. For instance, biodiversity is required for the provision of several ecological services (Hanson et al., 2012). Additionally,

biodiversity can influence the number, quality, and resilience of ecosystem services (Cambridge Conservation Initiative, 2020). Different practitioner perspectives, in which ecosystem service deterioration and biodiversity loss are seen interchangeably, also support this conclusion (De Nederlandsche Bank, 2020a; WWF, 2020). According to the UNPRI (UNPRI, 2020), ecosystem services require natural capital (=the assets) to provide their benefits to humanity. Biodiversity comprises the living component of natural capital and is thus essential for a continuous supply of ecosystem services. Figure 1 illustrates this association.

Figure 1: Relationship between natural capital, biodiversity and ecosystem services

Source: Cambridge Conservation Initiative, 2020

The majority of relevant research divides ecosystem services into four distinct categories: provisioning, regulating, cultural, and supporting (Millennium Ecosystem Assessment, 2005; Hanson et al., 2012; Roxburgh et al., 2020; FAO, 2021b, 2021c, 2021d, 2021a). Provisioning services encompass all the resources or raw materials extracted from ecosystems by people, such as wood, wool, food, fresh water, and medical resources. Secondly, regulatory services do not concentrate on the direct extraction of raw resources, but they are necessary for the existence of these elements in the first place. Examples include crop pollination, predator and parasite control in ecosystems, maintenance of air and soil quality, carbon sequestration and storage, and flood and disease management. Thirdly, cultural services emphasize the non-material advantages that humans receive from ecosystems, such as education, tourism, health, and recreation. Lastly, the supporting services are a larger category of services that are necessary for the proper operation of the other services, such as preserving genetic

variety or providing habitats. Such examples include nitrogen cycling and soil formation. However, it is also essential to recognize evolving or distinct taxonomies. For instance, a more recent IPBES categorization (IPBES, 2019) included simply the three categories of fundamental life support for people (regulating), material commodities (material), and spiritual inspiration (non-material).

Contrary to the preceding classifications, the ENCORE tool divides ecosystem services into four categories: direct physical input, production process enablement, mitigation of direct consequences, and protection against disruption (ENCORE, 2021c; UNEPFI, 2021). Examples of direct physical inputs include energy derived from animals, fibers and other materials, genetic materials, ground water, and surface water. Maintaining nursery habitats, pollination, soil quality, ventilation, water flow management, and water quality are examples that enables production processes. Bioremediation, dilution by atmosphere and ecosystems, filtering, and mediation of sensory impacts are examples for the set of techniques used to reduce direct consequences. Lastly, some examples of the protection against disruption category include mass flow buffering and attenuation, temperature management, illness control, flood and storm protection, mass stability and erosion control, and insect control.

From the above and previously cited statistics, it may be seen that enterprises are dependent on ecosystem services. In the provisioning category, forest products (timber and paper) contribute for USD 247 billion in global trade exports, which is a basic yet notable example (FAOSTAT-Forestry database, 2017). The pharmaceutical industry, in which 70% of cancer treatments are inspired by nature (IPBES, 2019), and the worldwide fishing industry, which is expected to be worth USD 362 billion (FAO, 2018), are further noteworthy examples. However, the other groupings of ecosystem services can also have a large effect on the global economy; for instance, the food industry is highly dependent on insect pollination.

Pollination is predicted to provide between USD 235 billion and USD 577 billion to the world agricultural food output (IPBES, 2019). In addition, 75% of the world's food crops rely on animal pollination (IPBES, 2019). Moreover, the value of soil biodiversity and the accompanying ecosystem services has been estimated to vary between USD 1.5

trillion to USD 13 trillion (Data European Soil Centre, 2021). Then there is the cultural service, an example of which is mostly tourism. Many tropical nations rely on functional coral reefs for tourism, which generates an annual worldwide tourist worth of USD 36 billion (Spalding et al., 2017).

The above-mentioned numbers are not completely unexpected. In 1997, Costanza produced the first estimates of the overall value of global ecosystem services, which totaled USD 33 trillion per year, about double the world GNP (Gross National Product) of USD 18 trillion at the time (Costanza et al., 1997). This was determined as an estimate of the overall value of 17 ecosystem services, with a range of USD 16 trillion to USD 54 trillion. Due to uncertainty, this was deemed by the authors to be a minimal value (Costanza et al., 2014). The annual value of ecosystem services was estimated to be USD 125 trillion in a research conducted by the same authors using the same technique, but with updated data and unit values (Costanza et al., 2014). Recent estimates by the OECD place the annual global value of ecosystem services at USD 125 trillion and USD 140 trillion (OECD, 2019). As seen by Costanza's and other researchers' publications (e.g., Turner et al., 2016), the computation of the value of all ecosystem services is extremely difficult and will likely never be precise. Nevertheless, and regardless of the inherent level of uncertainty, quantitative studies demonstrate the significance for enterprises and banks to better comprehend in their own language (i.e., monetary values) their (potential) dependence and influence on ecosystem services.

2.1.2 Risks for businesses

To perceive why banks face risks from BES, it is necessary to comprehend how companies suffer risks from BES. The literature and practitioner perspectives on this topic are inconsistent. Therefore, numerous risk groupings are offered in order to demonstrate to the reader the many concepts and reoccurring risk categories.

Research focuses primarily on the six basic forms of risk: operational, liability, regulatory, reputational, and market risk (Dempsey, 2013; OECD, 2019). When a company's operations depend on a raw commodity, such as wood or clean water, it faces operational risk. Degradation of BES can result in increased expenses for this raw

material or, in the worst-case scenario, the cessation of the original commercial operation. Liability risk is posed by the prospect that firms will be sued for BES destruction by other businesses that have sustained BES-related damages. If policies impose legal fines on firms as a result of new BES conservation laws, a regulatory risk will result. This may include limits on land and resource access, clean-up and compensation costs, procurement requirements, licensing and permission procedures, or moratoriums on the issuance of new licenses. The danger to a company's reputation stems from the waning interest of customers in particular brands, which is caused by the negative effects of BES. In contrast, a market risk is the likelihood that consumers would prefer BES-friendly companies. A financial risk is the chance that a company will lose access to the capital market if financial institutions tighten shareholder requirements. Then, banks and other types of investors would no longer invest in these specific enterprises.

WWF provides a similar classification. WWF has categorized nature-related dangers into five primary groups based on an assessment of 30 different frameworks (McCraine et al., 2019), comparable to the classification of the World Resource Institute (Hanson et al., 2012). The five risk groups are operational risk (e.g., resource scarcity leading to higher costs), regulatory and legal risk (e.g., fines, lawsuits, or government regulations), reputational risk (e.g., social awareness campaigns by NGOs targeting destructive businesses), market and product risk (e.g., customers favoring other (more environmentally friendly) businesses), and financing risk (e.g. banks implementing stronger lending requirements for corporate loan). In contrast to the preceding OECD risk category, the regulatory and legal risk incorporates the two groupings liability risk and regulatory risk (Hanson et al., 2012; McCraine et al., 2019).

Although these risks may seem obvious, global businesses do not account for them. An analysis of the Fortune 100 list (the 100 largest companies in the world) reveals that only a small number of companies include biodiversity loss in their reporting or take quantifiable measures against biodiversity loss (Addison et al., 2019). In the same research by KPMG and UNEP-FI referenced above, a qualitative examination of several BES risk assessments was utilized to identify sectors with a high risk of BES

reliance and impact. The evaluated reports produced a BES risk rating or indication for one or more industries. The food & beverage, oil & gas, and mining (including minerals) industries were deemed high-risk by this qualitative analysis. The research also indicates that industries such as extractives, construction, agribusinesses, and finance do not implement the necessary risk management to address the severity and effect of BES reliance (KPMG, 2011). UNEP has investigated the most reliant and important industrial sectors (the ones who damage biodiversity and ecosystem services the most) (Leach et al., 2020):

1. Agricultural Products (priority from both an impacts and dependencies viewpoint); 2. Apparel, Accessories, and Luxury Goods (priority from a dependencies perspective); 3. Brewers (priority based on dependencies); 4. Distribution (priority based on implications); 5. Electric Utilities (priority according to dependencies); 6. Independent Power Producers & Energy Traders (priority according to dependencies); 7. Mining (priority in terms of consequences); 8. Oil & Gas Exploration & Production (from an effect standpoint, the highest priority); 9. Oil & Gas Storage & Transportation (priority from impacts perspective).

Based on interviews with businesses in the United Kingdom, a research determined that the agriculture and forestry industry had the largest dependence on ecosystem services, while the financial services sector had the lowest. This study also revealed that for the evaluated enterprises, water quality and waste water treatment are of the highest significance for ecosystem service delivery (Watson & Newton, 2018).

2.1.3 The connection to banks

Banks are essential to a well-functioning economy because they serve as intermediaries between economic agents (Allen et al., 2014). Banks can convert financial resources from one economic agency into loan sources to stimulate other economic agents (Nițescu & Cristea, 2020). Therefore, banks invest in firms using a variety of financial instruments. Loans, equity holdings (e.g., equities) and bond holdings (e.g., tradable debt securities) are the primary ones (Battiston et al., 2017). Banks are a crucial source of external capital for businesses. In the European Union, banks provide the bulk of

external financing for enterprises (European Banking Federation, 2020b). In 2018, the 6,088 European credit institutions owned assets totaling 43,35[1] trillion euros, for example. From this total, non-financial firms received loans of EUR 5.5 trillion, but no information on equity ownership was released (European Banking Federation, 2020a). The ECB's periodically disseminated bulletin on "supervisory banking statistics" divides these numbers down even further (European Central Bank, 2021b). These papers include information on the largest banks in Europe, as defined by the ECB. The 112 banks included in the research owned assets totalling EUR 24,1 trillion at the end of 2020. This was comprised of 5 trillion euros in loans to non-financial firms and 2,9 trillion euros in debt securities (European Central Bank, 2020a). Debt securities were not further subdivided but comprise several sorts of financial assets, including equity holdings (European Central Bank, 2021a). Therefore, the (financial) sustainability of banks depends on the (financial) sustainability of the enterprises in which banks invest. And because these companies depend on BES, as described above, and are at danger due to BES failure, banks can also experience BES loss.

2.1.4 Risks for the financial sector with a focus on banks

Banks had the lowest degree of knowledge of the BES risk compared to all other studied industrial sectors; consequently, they must develop a deeper understanding of the risk in order to mitigate it (KPMG, 2011).

Together with WWF Switzerland, the University of Hamburg (Bassen et al., 2019) undertook a thorough literature assessment on the relationship between natural hazards and the financial industry[2]. To identify environmental hazards, the research focused on a variety of critical terms, such as "biodiversity loss" and "ecosystem devastation."

The investigation was unable to locate any empirical research on the effects of BES loss on the banking sector. The investigation uncovered 154 publications (published between 1967 and 2019) discussing the relationship between natural hazards and the

[1] These amounts were not broken down to a business sector classification

[2] According to the report, this was the first study of its kind besides one other study that has assessed the connection between climate change and the financial sector in 2019

financial industry (including banking, insurance, real estate, and the stock market), with the bulk focusing on the real estate business. The examination of 154 articles reveals that natural threats offer a financial risk via bank failures, a decline in stock prices (market capitalization), and a decline in home values (Bassen et al., 2019). Interviews with 75 of the world's leading asset managers showed a variety of significant conclusions about their biodiversity-risk strategies (ShareAction, 2020):

1. Biodiversity-risk related policies remain critically underdeveloped as asset managers lack specific commitments on biodiversity-related issues;

2. Climate change is examined more systematically than biodiversity-loss;

3. If biodiversity-related risks are examined, legal and regulatory risks are most frequently cited, with agriculture, forest and paper products and the extractive industry as focus sectors;

4. Asset managers do not incorporate biodiversity-related metrics.

The UNPRI has conducted study into the genesis of financial investors' risk exposure. According to a recent report by UNPRI, eight major factors contribute to a higher risk exposure of investors regarding BES risk: the sector of the investment, the geographic location, the regulatory frameworks, the market-capitalization, the operational arrangements, the value chain position (upstream versus downstream) of the investment, the degree of dependence and impact on biodiversity by the investment, and the ability of the business to substitute raw materials (UNPRI, 2020).

The WWF study (2019) describes the nature-related financial risks in further depth and provides the following instances of financial hazards: Increased cost of capital or lending requirements, decrease in asset value and total loss of assets, increased insurance claims, higher premiums, and loss of insurance value, increased risk of default, investment value loss attributable to reputational risks, and changes in the business's market value are all examples of risks (McCraine et al., 2019).

In 2020, WWF and PwC combined the McCraine et al. grouping with learnings from the financial risk groupings done by the Task Force on Climate-related Financial Disclosure regarding climate change, resulting in four different types of biodiversity-related financial risks that could be used by financial institutions and regulators (WWF, 2020): i) Risks associated with the transition to an economy that protects and recovers biodiversity; ii) Dangers relating to the physical effects of biodiversity loss; iii) Risks associated with litigation over biodiversity loss and violation of the underlying legal frameworks; iv) Risks associated with the systemic effects of biodiversity loss.

According to the Monetary Authority of Singapore (Monetary Authority of Singapore, 2020), environmental concerns can influence banks through either financial risks or reputational issues. Both types can arise from physical and transitional risk channels, which refer to the impact of long-term environmental changes or destructive environmental events as well as the transition to an environmentally sustainable economy via changes in public policy, new technologies, or consumer behavior. Credit risk, market risk, liquidity risk, operational risk, and reputational risk are the financial hazards that might result from this.

The Network of Central Banks and Supervisors for Greening the Financial System (NGFS) was founded in December 2017 by eight global central banks with the objective of bolstering the financial sector's efforts to achieve the goals of the Paris Agreement and enhancing risk management and capital mobilization in broader environmental and sustainable terms (NGFS, 2019b). Since its inception, the NGFS has expanded to 89 members and 13 observers throughout the globe, including the majority of European national central banks, their respective banking regulating bodies, and the ECB (NGFS, 2019a). As sources of financial risks, the NGFS (NGFS, 2020) identifies two major risk categories: physical hazards and transition risks. Both categories are comprised of several subcategories, however they may be summed up using these two phrases:

- Physical hazards encompass all direct effects resulting from environmental disasters or deterioration, such as extreme climatic events, ecosystem service losses, sea level rise, and environmental accidents;

- Transition risks encompass all impacts coming from human activity to alleviate environmental difficulties, such as policy adjustments, technology advancements, shifts in investment capital, and fluctuations in public opinion.

From these two environmental and climate-related risk categories, the NGFS identifies five financial risks that might occur via various transmission mechanisms. The five financial risks are credit risk (default of credit), market risk (declining value of assets), underwriting risk (increasing insurance gap and increasing losses of insurers), operational risk (disruptions in the supply chain or other operations), and liquidity risk (disruptions in the supply chain or other operations) (increasing demand for capital). The G20 (G20 Green Finance Study Group, 2017) and the Cambridge Centre for Sustainable Finance employ the same classification and transmission method for hazards (Cambridge Centre for Sustainable Finance, 2016).

2.2 TRANSITIONING FROM A RISK-BASED TO AN ALLOCATIVE GREEN CREDIT POLICY REGIME

The move to a sustainable economy[3] necessitates a fundamental reform of our economies and, by extension, of our financial flows. To reach net zero by 2050, clean energy investment alone must reach $4 trillion yearly by 2030, up from $1 trillion annually today (IEA 2021). The invasion of Ukraine has made the issue of energy decarbonisation and the question of funding renewables even more urgent. In addition, the higher inflation rates that may drive the green transition offer significant challenges to macroeconomic management (Schnabel 2022).

The macrofinancial facets of structural restructuring continue to be contested. Historically, central banks collaborated with ministries of finance and other government agencies to proactively guide credit and assist massive structural transformation of the sort required by the climate catastrophe, complementing active fiscal and industrial policy frameworks (Monnet 2018; Mikheeva and RyanCollins

[3] Which it is defined as a structural transition away from carbon-intensive/environmentally damaging activities towards low carbon/sustainable production and modes of living.

2022; Bezemer et al. 2021). Today, such cohesion is nonexistent. Fiscal authorities normally concentrate on carbon pricing, especially via carbon contracts for difference, but the green shift in central banking is primarily, though not solely, motivated by financial stability concerns (Schnabel 2021; Bank of England 2021b). In certain instances, central banks seek to mobilize private resources, as the Bank of Japan's green lending framework illustrates (Nishimura 2021).

The UCL Institute for Innovation and Public Purpose (IIPP) (Kedward, K., Gabor, D. and Ryan-Collins, J., 2022) distinguished analytically between a risk-based strategy to decarbonization and allocative green credit policy[4] (*Table 1*). The risk-based approach to decarbonizing private finance emphasizes market signals through improving price discovery and correcting relative pricing. Its overall idea is to outsource the speed and character of decarbonization to private finance, defined by the macro-financial status quo of monetary domination. In its current weak form, which dominates policy debates, it emphasizes risk exposures and relies on informational mechanisms such as improved disclosure of climate-related financial risks (TCFD 2017; NGFS 2019), as well as the development of sustainability taxonomies alongside scenario analysis and climate stress testing. These, it is hoped, would increase the efficiency of price signals, which have been undermined by market failure to price climate risks, and lead to a speedy reallocation of capital in line with the green transition (Christophers 2017; Chenet et al. 2021). The risk strategy, in its most robust form, includes incentive mechanisms that target relative pricing by de-risking green assets, such as the Bank of Japan's incentives for bank green loans or the European Central Bank's developing interest in green long-term refinancing operations (T-LTROs).

Despite its growing prominence and prioritization within mainstream policy circles, particularly in the last five years, the risk-based approach has failed to materially shift financial flows away from transition-incompatible activities and toward the rapid deployment of urgently needed green solutions. Indeed, bank credit to carbon-intensive sectors, including firms expanding fossil fuel reserves, has increased in the five years

[4] The term ‘credit policy' is used as a shorthand for policies that influence the allocation of flows of bank credit and institutional capital.

since the Paris Agreement was signed (Rainforest Action Network 2021), even in the Eurozone, where climate policy is widely regarded as among the most ambitious in the world (ECB 2020, p.73). Meanwhile, despite the market-led TCFD's introduction in 2017, climate-related financial disclosures have yet to influence investment allocation for the majority of financial institutions (Christophers 2019; Hook and Vincent 2020; Ameli et al. 2021).

Table 1. Articulating the differences between risk-based and green credit policy approaches to decarbonising finance.

	Risk-based approach		**Credit allocation policies**	
Paradigms vis-à-vis green transition	Monetary dominance; Market-led decarbonisation		Fiscal dominance; State-led green industrial strategy	
Purpose	**Prudential** – financial stability		**Promotional** – supporting industrial policy	
Focus	Enhancing price discovery; Correcting price signals (de-risking)		Steering credit to green sectors; Restricting credit to dirty sectors	
Mechanisms	**Informational**	**Incentive**	**Incentive**	**Coercive**
Policy targets	Transparency and disclosure	Relative prices through de-risking interventions	Sector-specific green targets on price and conditions of credit	Sector-specific green targets on quantity of credit, or credit growth (+ conditions)
Scope	Banks + standard financial assets (loans + bonds + equity)		Banks + whole ecosystem of institutional capital (+ private equity + repos)	

Source: Kedward, K., Gabor, D. and Ryan-Collins, J. (2022).

2.2.1 The risk approach is the developing status quote.

The prevalent market-driven, risk-based approach is a result of the existing macroeconomic status quo, which prioritizes "monetary supremacy." This is the (operational) independence of inflation-targeting central banks from fiscal authorities, together with fiscal and industrial conservatism, with fiscal policy considered essentially as (at best) a tool for short-term macroeconomic stabilization (Bernanke 2003)[5]. Given the dual assumptions of limited fiscal capacity and the supremacy of private credit markets for effectively allocating capital, the state is anticipated to aid

[5] The massive fiscal expansions that occurred during the Covid-19 crisis, apparently accommodated by central bank Quantitative Easing programs, have led some to question monetary dominance (Bartsch et al. 2020). However, the Covid-crisis has not, as yet, lead to any major or permanent institutional shifts in macro-economic policy frameworks. For example, fiscal rules pertaining to the size of the budget deficit or debt-to-GDP ratio have been reimposed in high-income economies, alongside price stability remaining the dominant objective of monetary policy.

private finance in its efforts to lead the green transition (Bezemer et al. 2021; Gabor 2021). State assistance is essential to redirect the trillions of dollars of private finance, such as the USD 130 trillion of the Glasgow Financial Alliance for Net Zero, from dirty to green businesses, whose greater risks relative to profits and intense capital needs discourage investment.

Under this macro-financial framework, risk-based policy seeks decarbonisation via a two-pronged strategy: enhancing price discovery (market-fixing) and adjusting price signals (de-risking). Both ultimately cede to the private sector the speed and direction of the green transition and the associated capital reallocation dilemma.

The objective of market-fixing techniques is to increase the clarity and availability of climate-related data and to stimulate the internalization of climate-related risks into market pricing. Not only is it expected that climate-related risks are quantifiable, but also that private actors would incorporate such knowledge into capital allocation choices. As a result, systemic risks will be mitigated as actors sensibly manage their individual risk exposures. It is not a surprise that a risk-based approach has grown predominant among central banks worried about the climate catastrophe. Disclosure and openness of risk is crucial to the worldwide Basel III regulatory framework and has therefore become a pillar of the developing agreement on climate risk management (e.g. see NGFS 2019). This risk-based reasoning is also consistent with the 'prudential' reasons of these organizations' core responsibilities (Baer et al. 2021; Chenet et al. 2021). Consequently, the green policies of central banks and regulators in high-income countries have prioritized the development of scenario-based risk analysis methodology and the incorporation of climate risk disclosure efforts spearheaded by the private sector (e.g. Bank of England 2019; ECB 2020; NGFS 2020).

De-risking tactics supplement market-fixing strategies by modifying the risk/return profile of financial assets to more closely fit with the preferences of market-based financial players (Gabor, 2021). Here, the de-risking state socializes a series of risks (liquidity, political, demand, or exchange rate) to mobilize private finance for public purposes, based on the conservative macroeconomic assumption that there is

insufficient fiscal space for public investment, combined with the market constraint that the high risks of capital-intensive green projects discourage private investors.

Carbon contracts for difference, which are essential to the EU's RePower Europe ambitions, are a fiscal risk-mitigation instrument that encourages private investment in renewable energy. In the Global South, a 'Wall Street Consensus' headed by the World Bank pushes nations to accomplish the SDGs by entering into de-risking partnerships with institutional capital to create investible assets in social and other infrastructure (Gabor 2021; Musthaq 2021). More recently, there have been demands to extend de-risking tactics to environment conservation, namely by classifying "natural capital assets" as public infrastructure and creating "new asset classes for nature" based on integrated finance (Deutz et al. 2020; Paulson 2020; Lankes 2021). These measures should be understood in the context of a larger macro-financial shift in favor of regulatory, monetary, and fiscal de-risking of several assets, such as climate, infrastructure, housing, and government bonds (Dafermos et al. 2020). These informational and incentive systems try to reallocate private money flows in a "orderly" manner. However, unlike the credit guidance policies used in the 20th century, the risk approach does not explicitly strive to match sector-specific capital prices and quantities with a specified decarbonization plan. Utilizing market-fixing solutions successfully defers sectoral allocation choices to the private sector, which is supposed to analyze climate risk information objectively and efficiently reallocate capital appropriately (i.e., a "deferential transition"; see Smoleska and van 't Klooster 2022). By boosting (decreasing) the relative price of dirty (green) credit produced on bank balance sheets or asset markets through signaling and demand effects, policy interventions are aimed to support this endeavour.

Aligning asset purchase portfolios and collateral frameworks with climate transition plans, for instance, successfully use the central bank's balance sheet as a large buyer and market maker of sovereign and corporate bonds to directly impact but not fix the market price of credit. The purchasing power of the central bank can reduce yields and, consequently, borrowing costs for enterprises and industries judged suitable for these programs, while boosting it – in relative terms – for those that are excluded.

Demand impacts are second-order since the corporate bond and collateral portfolios of central banks are tiny relative to the assets owned by global financial institutions (Hauser 2021, p.8).[6] In turn, central banks have emphasized the significance of signaling effects in communicating to markets their views on green vs polluting assets (e.g. Bank of England 2021; Weidmann 2021).

Importantly, risk-based policy keeps its institutional commitment to monetary supremacy, even when new green requirements would legitimize a closer alignment between the central bank and government transition plans. In an examination of climate change implications for monetary policy, for instance, the Network for Greening the Financial System (NGFS) evaluated prospective monetary and credit policy choices based on a perceived trade-off between climate mitigation/risk protection and monetary policy efficacy (NGFS 2021). Despite the possible operational problems, the analysis highlighted market-dependent strategies (such as price changes to collateral haircuts and targeted refinancing operations) as perhaps the most effective (e.g., collateral haircut pricing adjustments and focused refinancing activities).

Consider the instance of the Bank of England, one of the first major central banks with a stated environmental mission, to elucidate the analytical purchase of macro-financial knowledge of the risk approach. Its decarbonization policy appears to go beyond a risk-based approach; in November 2021, for instance, it announced intentions to "green" its corporate bond purchasing scheme (CBPS). Nonetheless, a macro-financial view fits this occurrence squarely within the risk-based approach for two reasons. First, the escalation approach is expressly directed by market neutrality, employing price-based incentive mechanisms at intra-sectoral level to prevent overt allocative actions that may be characterized as industrial policy (Dafermos et al., 2022). In reality, this implies that the Bank would slant reinvestments *within* sectors but not *across* sectors — for instance, by purchasing the "best-in-class" fossil-related corporate bonds (as judged by

[6] By the Bank of England's own calculations, its £20 billion corporate bond purchase scheme (CBPS) accounts for just 6.5% of the sterling corporate bond market, 0.5% of all sterling traded assets, and just 0.01% of assets held by global financial institutions (Hauser 2021). At over ten times its size, this would make the ECB's corporate sector purchase programme – one of the largest of its kind in the world – account for around 0.11% of total institutional assets globally.

a scorecard of numerous climate parameters[7]) rather than agreeing to eliminate the sector entirely (Bank of England 2021a). Second, when inflation began to increase, the subordination of the de-risking strategy to the primary aim of price stability led the Bank to abandon its decarbonization ambitions in February 2022 and resolve to unwind its corporate bond portfolio by the end of 2023 for quantitative tightening purposes. With its institutional separation of monetary, fiscal, and industrial policy, the Bank's approach thereby protects the macro-financial architecture of monetary supremacy. Kedward et al. (2022) suggest that this is significant because it subordinates and may easily sacrifice decarbonization to the purpose of price stability. Instead, in accordance with a risk-based approach, the Bank has essentially abdicated its policy responsibility for speeding the decarbonization of private finance, outsourcing its pace and direction to private capital.

Global climate reactions also reflect the risk-based approach in action. For instance, the Swedish government will guarantee up to 80 percent of the principal long-term loans to large-scale green industrial projects. In recent years, l'éco prêt à taux zero, a long-standing zero-interest home loan program administered by domestic banks (who get remuneration in the form of subsidies) has been extended to green housing retrofits. Both the Bank of England and the European Central Bank (ECB) have examined suggestions for green targeted refinancing operations and differentiated capital requirements (Cox 2020; Baranovic et al. 2021; PRA 2021). However, both sides have claimed that proof of an established risk difference between green and polluting enterprises is required to support the adoption of such laws (e.g. PRA 2021). By June 2022, no central bank or regulator in high-income nations will have specifically penalized filthy assets. Similarly, despite acknowledging that the operational principle of market neutrality hardwires a carbon bias in monetary policy operations (e.g. Schnabel 2021),[8] many central banks have been reluctant to abandon market neutrality

[7] The climate scorecard will take into account (1) the latest level of the firm's carbon intensity, measured by CO2e emissions per million pounds revenue; (2) backward-looking measures of past change in absolute emissions, measured as a weighted moving average over the past 3 years; (3) how firms' climate-related financial disclosures compare to sector standards; (4) the presence (or not) of emissions reduction targets, with extra credit for those validated by a third party.

[8] Since 2010, central banks have organised unconventional corporate bond purchases under market neutrality, reproducing relative market shares to avoid privileging any particular bond issuers. Yet in

entirely; a decision made to preserve the appearance of independence against (conservative) charges that green monetary/regulatory policies are incompatible with operational independence (e.g. Gros 2020). Therefore, the overt questioning of market neutrality assists to establish legitimacy for de-risking actions rather than credit allocation rules that are strict. The Bank of Japan (BoJ) is the most prominent example in this respect, since it was the first major central bank to establish a green targeted refinancing operation in 2021, allowing banks to access long-term zero-interest refinancing for green lending until at least 2031. Despite accepting the constraints of market neutrality in theory, the BoJ has been unequivocal in stating that credit allocation choices, including the interpretation of whether a loan is "green" or not, would be left exclusively to banks (Clarke 2022). The Bank of Japan is instead confident that climate risk disclosure frameworks (most notably the private-sector-led TCFD) will serve as disciplinary measures against greenwashing (Nishimura 2021). This reassertion of a market-neutral stance is especially noteworthy coming from the central bank that has engaged most extensively – both in terms of scale and breadth – in domestic financial markets, notably equities markets, via its multiple quantitative easing programs.

Overall, these examples indicate that even at its most ambitious, decarbonization under monetary supremacy equates to a risk-based approach that focuses solely on the relative pricing of green/dirty credit. From this perspective, the primary objective of central banks is to influence market prices through demand and signaling effects triggered by adjustments to the relative quantities of dirty/green corporate bonds held in unconventional portfolios or to the terms under which these bonds are accepted as collateral. Critically, as shown by the Bank of Japan, the criteria for determining such sector-wide changes do not correspond with a government plan to encourage or prohibit certain industries. Rather, the sectoral allocation decision is mainly delegated to market-derived assessments of climate risk, with private finance being viewed as the most capable of allocating capital after such risks are considered. The risk-based approach

practice ‘following the market’ means that central banks replicate existing market failures in (mis)pricing climate risk, thereby implicitly subsidizing carbon issuers (say Shell) when purchasing corporate bonds. A similar subsidy arises within the collateral framework underpinning conventional interest rate policies, where central banks accept collateral at market prices.

delegated the specific speed and type of the transfer to private finance in this manner. As acceptable policy choices, quantity-based credit allocation plans are rejected (or not even evaluated). It is unclear whether this is due to a persistent belief that such intervention would lead to the inefficient allocation of investment (distortion critique) (Bezemer et al. 2021) or whether it has more to do with concerns over central bank independence and the strict institutional separation of the monetary and fiscal spheres ('mission creep').

2.2.2 The renewed case for allocative credit policy as a step toward an alternative macro-financial regime

To minimize economic and financial instability, the green transition necessitates simultaneously boosting the growth of green innovation across new and current industries and regulating the orderly collapse of "transition-incompatible" sectors. Alternative approaches frame decarbonization as a 'wicked problem' (Rittel and Weber, 1973) involving dynamic structural change, encompassing multiple sectors and agents, supply and demand dynamics, lock-in effects, and uniquely predicated upon the complexities of rapidly deploying and diffusing innovative technologies. Heterodox schools of thought, such as political economy, systems thinking, and evolutionary economics, acknowledge that there are various possible outcomes that may be impacted by the way the state proactively engages with other economic players (Geels and Schot 2007; Kattel et al. 2018). From this vantage point, the green transition is not a plan for de-risking private investment nor a green version of Keynesian demand-side stabilization, but rather a complete industrial strategy designed to foster the circumstances for a quick structural economic shift (Mazzucato and McPherson 2018). Instead of a 'de-risking state' that accompanies private capital into green(washed) activities, this perspective proposes a 'market-shaping' role for public policy, premised on public investment in strategic priority sectors and policy coordination between fiscal, industrial, financial, and regulatory spheres (Mazzucato et al. 2020; Kedward and Ryan-Collins 2022). It should also provide explicit disciplinary processes for both green industrial winners and financiers of polluting assets (Gabor 2021). This necessitates a new macro-financial structure for central banking and financial

regulation. Such a framework would not be characterized by a narrow focus on short-term price stability, financial stability, and operational independence, but rather by a broader suite of policy tools – coordinated with other government departments – that are better aligned with democratically determined goals of the green transition and will more effectively support long-term macro financial stability. Particularly, fiscal and industrial policy will be required to play a leading and expansionary role in accelerating the green transition, with central banks increasingly required to play a 'promotional' (rather than 'prudential') role (Baer et al., 2021) – aligning financial regulation, credit, and monetary policies with green industrial strategy to ensure that the dynamics of private capital allocation do not undermine this policy effort (Kedward and Ryan-Collins 2022).

The allocative credit policy framework lays a stronger focus on environmental effects as proof of materiality and as rationale for policy intervention, as opposed to the existing reliance on market-derived predictions of climate risk only in terms of financial materiality. Given the limits of risk-based approach discussed in the preceding section, Kedward et al. (2022) suggest that sector-specific objectives on both quantities and prices must be the key mechanisms for ensuring the orderly reallocation of capital under extreme uncertainty. Post-World War II, high- and middle-income nations utilized credit allocation policies to assist fundamental economic transformations and fast industrialization, including as instruments to control credit expansion in speculative or undesirable sectors (Bezemer et al. 2021; Mikheeva and Ryan-Collins 2021). These were also referred to as "credit guidance," "credit limitations," "credit limits," "directed credit," "window guidance," and "moral suasion" (ibid.). For instance, Japanese and Chinese window guidelines incorporated quantity-based limits for lending to specific industries (Werner, 2003), including for sustainable reasons (Dikau and Volz 2021). More recently, it has been demonstrated that informal mechanisms of state-bank cooperation, such as moral persuasion, were significant in guaranteeing adequate bank involvement in state-guaranteed loan programs during the COVID-19 economic crisis in Europe (Massoc 2021).

Since the 1980s, several nations have abandoned clearly allocative lending rules as part of financial sector liberalization. This move was justified by theoretical arguments that credit regulations promote mispricing of capital, affecting the efficient allocation of credit and resulting in lower levels of productive investment (McKinnon, 1973; Shaw, 1973; Mayer, 1975). The 'distortion criticism' derives from neoclassical theory, in which credit is conceptualized as stemming from the market for limited 'loanable funds' - i.e. scarcity - and as being decided by price signals under circumstances of perfect competition. From the 1980s onward, it provided the theoretical basis for the World Bank and IMF to reject credit programs and embrace financial reform and the privatization of state investment banks (SIBs) (Gelb, 1989; Caprio and Honohan 2001). Numerous criticisms have demonstrated, however, that banks deliberately ration credit; hence, the market-determined interest rate cannot be seen as a valid measure of efficient credit allocation (Stiglitz and Weiss, 1981; Wolfson, 1996; Dow, 1996; Ramskogler 2011). Quantity-restricted markets are not characterized by a price equilibrium, but rather by quantity determination on the supply side (in this example, the bank), regardless of the interest rate. Understanding the influence of finance on macro-economic variables becomes much more dependent on quantity variables — the amount of credit and where it is distributed in the economy — in this scenario (Werner 2005; Bezemer et al. 2021). In addition, the systemic market failures to price climate risks and the inadequacy of the de-risking credit policies mentioned imply that allocative credit interventions are required to enable an orderly decarbonization.

2.2.3 Institutional challenges and other areas of research

The allocative green credit strategy tries to overcome the market-driven, risk-based approach's weaknesses in three primary ways. First, it significantly broadens the scope of credit regulation to include the larger ecosystem of market-based finance — a crucial tool to combat the possibility for regulatory circumvention and "backdoor" credit generation via shadow intermediaries, which might derail the green transition. Second, it abandons the use of 'objective' risk-based criteria to guide sectoral adjustments in favor of discretionary criteria that aim to align the direction of financial flows with green industrial policy objectives – an approach that takes into account the

difficulties in quantifying 'radical uncertainty' environmental risks. Thirdly, the framework reasserts democratic control over the provision of green and dirty capital, in the context of a broader ‘market-shaping' role of the State in expediting the green transition via mission-oriented industrial policy (Mazzucato et al. 2020). This transition away from reliance on private-sector-led "ESG" projects has the possibility to better fight entrenched corporate interests and the hazards associated with greenwashing.

Significant problems arise regarding the consistency of allocative green credit policy with the restricted 'prudential' mandates of many central banks and financial regulators in high-income economies. Some have suggested that direct interventions in credit distribution might be justified by the necessity for preventive policy action to avert the formation of potentially catastrophic hazards and the problems posed by extreme uncertainty (Chenet et al. 2021). Others claimed that linking the private financial sector with the government's Net Zero transition goals might be a more effective and, thus, responsible method of minimizing systemic climate risks (Robins et al. 2021; Barkawi and Zadek 2021). The credit policy has the potential to affect an orderly transition by instilling trust in private sector players by outlining a trajectory for capital allocation consistent with green transition goals. It is also crucial to note that the suggested allocative green credit policy framework provides policymakers with trade-offs that have larger institutional ramifications. There is no clear historical precedence for using credit allocation policies to promote the growth and dissemination of new innovation-intensive businesses while simultaneously controlling the decline of legacy sectors and doing so may pose dangers to macrofinancial stability.

First, dirty penalties may provide transitional hazards in some industries. This trade-off might be addressed by using credit policy in careful coordination (e.g., on a "escalating" basis) with a comprehensive suite of industrial policy tools meant to reduce the economic dislocations associated with shifting industries. This requires far greater institutional coordination between financial and fiscal/industrial policy than the current macrofinancial environment deems adequate. Second, and relatedly, dislocations in legacy sectors may have inflationary effects if emerging green sectors are unable to quickly absorb extra labor and capital — dynamics that are now occurring in energy

markets, albeit under geopolitical rather than transition-related conditions. In order to facilitate the green transition, central banks may need to evaluate the extent to which they may accept short- or even medium-term inflation, bringing into question the existing inflation-targeting framework. In a broader sense, it may be argued that controlling credit amounts through policy is already incompatible with inflation-targeting, as this means that prices are no longer decided by the market. One possibility may be to disaggregate inflation measurements and further define inflation objectives and policy instruments of central banks. Additional study is required to answer these questions.

Managing these trade-offs without falling into the trap of 'green technocracy' implies that central banks and financial regulators must shift from a 'prudential' to a 'promotional' institutional role (Baer et al. 2021) in order to effectively manage radically uncertain environmental risks and ensure an orderly 'greening' of the financial system. Therefore, the allocative green credit policy framework suggested in the research of Kedward et al. (2022) should be viewed as part of a new macrofinancial "supercycle" for the green transition (Dafermos, Gabor and Michell 2020). This new institutional framework prioritizes direct coordination across fiscal, monetary, prudential, and industrial policy realms, as well as the subordination of credit and monetary policy to serve the demands of green industrial policy (see also Braun and Gabor 2022). From this vantage point, credit policy must be "brought back in from the wilderness" (Borio and Lowe, 2004) to serve as "thwarting mechanisms" (Ferri and Minsky, 1991) that ensure regulated banks and market-based finance can align with – or at the very least not undermine – democratically determined policy for a green structural transition.

Direct credit policy interventions will assure transition-related capital reallocation more effectively and promptly than the existing risk-based approach. Several enabling policy adjustments will be necessary to operationalize the allocative credit policy framework. First, a public taxonomy that identifies harmful activities that are incompatible with government transition objectives and for which capital allocation must be reduced as soon as possible. To support larger green industrial policy objectives, national

governments should also designate priority activities and sectors where financing has to be scaled up immediately. Second, obligatory disclosures of portfolio composition to priority and dirty activities, together with mandated phase-out plans for the latter, are needed for both regulated lending institutions and institutional capital. Lastly, Kedward et al. (2022) advocate for the establishment of new national public agencies comprised of representatives from central banks and relevant financial supervisory bodies, as well as ministries of finance, industry, and environment/climate, that could coordinate the design and implementation of green credit policy, as well as monitor its ongoing effectiveness in supporting green industrial strategy[9]. While each of these enabling proposals represents significant reforms, policymakers should consider that these exercises may be more feasible within the remaining urgent timeframes for transformative action than the herculean evolution in metrics and risk modeling necessary to fulfill the current risk-based regime.

2.3 ASSESSING FINANCIAL STABILITY IN THE CONTEXT OF BIODIVERSITY LOSS: DIFFICULTIES AND POSSIBLE SOLUTIONS

The missions of central banks and financial regulators vary by country, but often involve the maintenance of financial stability. Given the intricacy of the linkages between biodiversity and the economy, it is difficult for central banks and financial supervisors to comprehend the transmission of biodiversity-related risks from the macroeconomy to the financial institutions and systems they supervise. Currently, analytic attempts to investigate these activities are commencing.

Based on a greater understanding of the potential for biodiversity loss to generate material economic and financial impacts, the next question for central banks and financial supervisors is: how do we assess the potential for biodiversity loss and the measures taken to address it to create financial risks that threaten the stability of

[9] See Mikheeva and Ryan-Collins (2022) for discussion of historical examples of these types of bodies and how they supported industrial transition in the post-war period. See also Krebel and van Lerven (forthcoming) for a discussion on how such an institution could be introduced within the UK context.

individual financial institutions and the financial system as a whole? This is the chapter's subject matter.

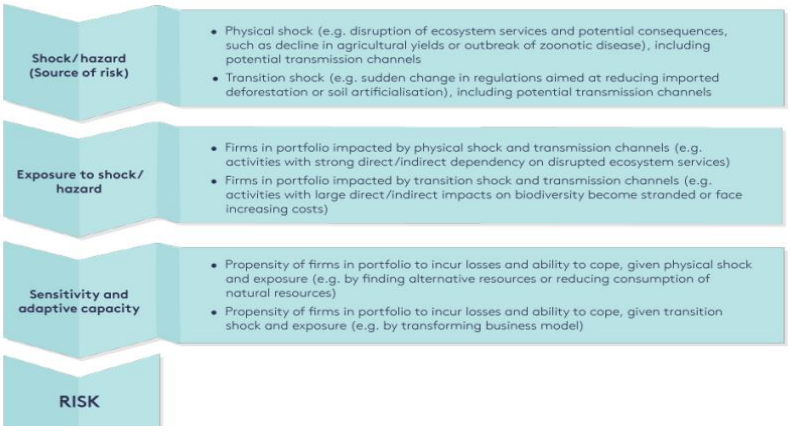
2.3.1 How to conduct a biodiversity-related analysis with a view to the future

To comprehend the influence of biodiversity-related hazards (or any environmental risk, for that matter) on financial stability, three components are required (Figure 2):

1. A scenario of the dangers or shocks that might lead to financial concerns; 2. exposure metrics for the asset portfolios of financial institutions to these risks/shocks; 3. instruments for determining the sensitivity and adaptability of these financial institutions and their portfolio firms in terms of their vulnerability.

However, the difficulties outlined in the preceding chapter make it difficult to gain a comprehensive understanding of any of these components. It is notable that comparable constraints apply to the evaluation of climate-related financial risks, however the complexity of biodiversity-related financial risks makes it more vital to solve these concerns.

Figure 2: From environmental hazards to financial risk



Source: Reproduced from Svartzman, Espagne et al. (2021)

First, the nature of possible dangers or shocks connected to biodiversity is unknown, as are the mechanisms via which they may be conveyed to economic agents. In contrast to climate-related financial concerns, no ad hoc scenarios for use by central bankers

and financial supervisors have yet been developed (see NGFS, 2021). As is the case with climate change, the physical and transitional effects of biodiversity loss can be either acute (rapid) or chronic (dispersed over time). Ecosystems might collapse abruptly, and policies could be implemented that result in a quick revaluation of assets. On the other hand, physical hazards could manifest gradually, and policies to halt biodiversity loss could be implemented gradually. As soon as investors become aware of these incremental alterations, there may be a dramatic revaluation of assets (Brunetti et al., 2021). Second, assessing the exposure of economic and financial agents is complicated by the fact that many hazards and shocks are likely to have highly localized effects (requiring specific local data and/or an understanding of local natural phenomena and processes), but can also have ripple effects across ecosystems and supply chains. For instance, the expansion of protected areas would have the greatest impact on enterprises with manufacturing facilities or suppliers in the future protected area. However, globalized supply networks may convey local effects throughout the globe, possibly amplifying small-scale effects to a much larger size. Similarly, physical influences on the functioning of an ecosystem, such as disruption of disease management, might lead to the emergence of a new zoonotic disease that, like COVID-19, could have significant global repercussions. Thirdly, exposure does not always equate to susceptibility, since certain agents, sectors, and nations will be more adaptable than others. To evaluate risk, it is vital to comprehend the susceptibility of agents to shocks and their capacity to withstand the resulting impacts or losses. A business that has the majority of its facilities or suppliers in a newly designated protected area may be able to quickly relocate those facilities or locate new suppliers. In contrast, a corporation may have little exposure to a certain provider but find it hard to locate a suitable alternative. This means that when central bankers and financial regulators begin assessing the financial risks associated with biodiversity, it is essential to keep in mind that we face a scenario of profound or radical uncertainty (Bolton et al., 2020; Chenet, et al., 2021; Kedward et al., 2020).

Therefore, no one model or scenario can offer a comprehensive picture of the possible macroeconomic, sectoral, and firm-level effects of biodiversity loss due to the profound uncertainties involved with natural processes and ecological tipping points.

2.3.2 Medium- to long-term strategies for assessing the effects of biodiversity loss on the economy and monetary system

Central bankers and financial regulators have two primaries medium- to long-term methods for assessing financial risks associated with biodiversity. These approaches may be viewed as complimentary rather than exclusive, since they offer distinct perspectives through which one can evaluate the connections between biodiversity, the economy, and the financial system.

Existing biodiversity–economy models, might serve as inputs for the evaluation of financial hazards. A case in point is one of the physical risk evaluations undertaken in Brazil by Calice et al. (2021). The authors expand on the global Earth-economy model, which gives country-specific estimates of the drop in GDP growth from 2021 to 2030 (taking 2021 as a baseline) as a result of a collapse in a selection of ecosystem services. The outcomes of the model indicate that Brazil's GDP growth might be 10% lower by 2030 than in a business-as-usual scenario. The authors then "insert" these data into a financial risk assessment, employing research that evaluate the historical sensitivity of Brazilian banks' asset quality to macroeconomic conditions (particularly, the link between borrowers' repayment ability and macroeconomic conditions). Other factors being equal, they conclude that the GDP losses associated with the collapse of ecosystem services might result in a cumulative 9 percentage point rise in corporate nonperforming loans (NPLs) over the long run. It is essential to remember that, due to the inherent limits of biodiversity–economy models, the exercise yields only conservative estimates of the economic and financial repercussions of deteriorating ecosystem services, as noted by the authors.

Given these obstacles, the second course of action is to create new methods for assessing financial risks associated to biodiversity. Two recent breakthroughs in the literature offer intriguing pathways for comprehending the propagation of biodiversity-related financial shocks.

To begin with, current literature on climate-related financial risks might be utilized to gain a better understanding of how biodiversity-related shocks could cascade throughout economic sectors and throughout global supply networks. One research utilizes input-output tables to illustrate how climate-related problems due to asset stranding might spread from one economic sector to another that rely on the first for production inputs (Cahen-Fourot et al., 2021). Similar methodologies would be especially useful for measuring the transmission of hazards if irreplaceable kinds of natural capital were to get stranded. With a better knowledge of these cascading effects, it is possible to better assess the vulnerability of individual companies (but not their adaptability). Godin and Hadji-Lazaro (2020) utilize two financial indicators (net debt over gross operating surplus and net debt over total assets) to examine the financial repercussions of a loss of exports from carbon-intensive sectors cascading onto other sectors.

Future evaluations of biodiversity-related financial risk might potentially be applied to the risk of financial system-wide contagion. Such contagion may occur, for example, if biodiversity-related shocks impacted the market values of some sectors and enterprises and diminished the capacity of some borrowers to service debt. Roncoroni et al. (2021), focusing on climate-related financial risks, demonstrate that very moderate initial environmental shocks might end up spreading across the financial system via the network values of financial assets. Due to the low substitutability of natural capital, there may be numerous channels through which biodiversity-related financial risks could spread throughout the financial system, including bank insolvency, market liquidity, and fire sales, potentially affecting agents distant from the source of biodiversity loss.

In addition, these transmission channels are likely to operate in both directions: financial consequences may leak back into the real economy via credit limits and increased lending rates, so influencing output, investment, employment, etc.

3 METHODOLOGY

Data and analytics availability and capability are critical success factors for the achievement of the TNFD's goal to provide organisations with a framework to report on the risks arising from biodiversity loss and ecosystem degradation. Improved data and information availability will enable organizations to integrate these risks more accurately and reliably into decision making. As the Dasgupta Review on the Economics of Biodiversity highlighted, standardised, credible, decision-useful data is required to underpin global standards that enable companies and financial institutions to report and act on nature-related risks and opportunities. Data availability, quality and ease of use will be driven by:

- the development of metrics and indicators;
- the growing adoption of nature-related targets in corporate strategy and reporting; and
- innovation of new tools, services and capabilities.

To explore current challenges and future priorities in the nature-related data landscape, this section has adopted a case study approach. The following case study explore challenges, key issues and potential data development opportunities through the lens of the TNFD's beta risk assessment process for nature-related risks and opportunities, known as LEAP.

3.1 INTRODUCTION TO THE TNFD NATURE-RELATED RISK AND OPPORTUNITY ASSESSMENT APPROACH: LEAP

Since the launch of the TNFD, market participants have indicated that simple, accessible guidance on how to understand and respond to nature-related risks and opportunities would be a welcome complement to a set of disclosure recommendations. In response, the TNFD has developed an integrated assessment process for nature-related risk and opportunity management called LEAP.

- Locate your interface with nature;
- Evaluate your dependencies and impacts;

- Assess your risks and opportunities; and
- Prepare to respond to nature-related risks and opportunities and report.

Figure 3: LEAP Methodology

Source: (TNFD) Task force on Nature-related Financial Disclosures' website

The LEAP approach is voluntary guidance intended to support internal, nature-related risk and opportunity assessments within corporates and financial institutions to inform strategy, governance, capital allocation and risk management decisions, including disclosure decisions consistent with the TNFD's draft disclosure recommendations.

LEAP has been designed and developed with three overarching considerations in mind:

- The LEAP approach encourages users to carefully consider the scope of their assessment before commencing;
- Analysts and preparers are encouraged to consult with relevant stakeholders as they work their way through the LEAP approach; and
- LEAP is designed as an iterative process – across business locations, business lines for corporates, and across investment portfolios and asset classes for financial institutions – in line with enterprise risk management processes and reporting and disclosure cycles.

This early prototype of LEAP has been designed as a general approach for use by a wide range of corporates and financial institutions. The TNFD recognizes that a general approach is difficult to develop, given variations in business models, sector-based market dynamics and the information needs of users. Financial institutions, in particular, have different decision making and information requirements to corporates; and there is significant difference among financial institutions.

The TNFD also recognises that some organisations may already have an equivalent process built into their enterprise risk management framework. In such cases, the LEAP approach can be used as a checklist to ensure existing internal processes adequately address nature-related risks and opportunities.

Finally, in developing the LEAP approach, the Taskforce has built on and integrated existing, high-quality nature-related frameworks, tools, data sources and other guidance developed by a range of other organizations that are aligned with the TNFD's principles and approach. The source frameworks and tools used are signposted throughout the phases of the LEAP approach, with descriptions of how they may be used by organisations. As new frameworks, tools, data sources and guidance are developed, the TNFD will add additional signposts into the LEAP approach.

3.2 SELECTION OF THE BANK FOR THE CASE STUDY

A combination of reasons influenced the final selection of the bank to be examined as a case study in this thesis.

During 2022, I had the opportunity to work as 'ESG Junior Consultant' at the consulting firm "PwC Italy," where owing to the different workshops offered by the company, I was able to interact with the bank's sustainability-focused associates.

I was able to interact personally with the associates during the meetings in which the bank's internal processes were presented in order to appropriately address the risks and opportunities related to nature. This allowed me to collect all the additional information necessary to perform the case study.

In addition to the luck of being able to interact with experts in the field of interest, the choice of a purely Dutch bank comes in part from my Dutch Erasmus experience at the renowned University of Maastricht (School of Business and Economics) during the academic year 2021-2022, where some topics on nature-related risks and opportunities were already being examined, which led me to realize that the Netherlands is one of the most environmentally conscious nations in the world. Indeed, De Nederlandsche Bank (DNB) was the first central bank to quantify the extent to which the financial institutions it controls are exposed to risks from biodiversity loss (van Toor et al., 2020). It was determined that 36% of Dutch financial institutions' investments are highly or extremely dependent on one or more ecosystem services. Ecosystems that offer both groundwater and surface water exhibited the greatest dependence.

In this regard, Triodos Bank was chosen, which is a bank with a strong focus on financing the Food and Agribusiness (F&A) sector, its concerned that the sector - and thus its exposures to companies in the sector - may be exposed to a high level of nature-related risk, specifically in relation to water issues.

3.3 CASE STUDY

Triodos Bank N.V. is a bank based in the Netherlands with branches in Belgium, Germany, United Kingdom and Spain. It was founded in 1980 and as of 2021, Triodos Bank has over 750,000 customers worldwide. Triodos Bank finances companies which it believes add cultural value and benefit to both people and the environment. To evaluate its exposure, Triodos carried out its own assessment to identify key risks and opportunities associated with its different exposures to food manufacturing companies.

Locate

Triodos gathers geographic asset-level data for its investment portfolios in its asset management business as part of its pre-transaction due diligence and decision-making process. In the absence of this data, the firm estimates asset level locations based on publicly accessible data and third-party geospatial data (such as GISTImpactxiii). Accessing location data upstream of the portfolio firms, such as supplier assets, is

difficult, thus the company depends on country-level estimations of supplier locations derived from input-output modeling and data from suppliers like Exiobase. Notably, input-output modelling is primarily employed by Triodos in the Evaluate phase of the LEAP process to analyze the extent and scope of impacts, but its results also help this country-level location assessment in the Locate phase.

Where primary geographic data was available, the WRI Aqueduct Water Risk Atlas was utilized to estimate the proportion of its enterprises' operations in water-stressed regions. Approximately 10% of Triodos's capital were discovered to be invested in French food manufacturing enterprises working in water-stressed regions. Using tools like the WRI Aqueduct Water Risk Atlas, the following factors were identified as contributing to the region's high water risk rating:

• The ratio of total water withdrawals and consumption to available renewable surface and groundwater supplies;

• High inter-annual variability and high drought risk; and high coastal eutrophication potential affecting water quality.

Triodos screens its loan portfolios for nature-related "red flags" using its developed Environmental and Social Risk Management framework (ESRM), which includes sector-specific regulations pertaining to themes such as forestry and fisheries. This establishes very simple minimal criteria when assets interact with nature (e.g. signaling "red lights" where Triodos's financing activities may interact with biodiversity hotspots, UNESCO biospheres, RAMSAR wetlands, and other regions of high ecological significance. Tools like IBAT and InVEST were utilized to assist in this evaluation). As part of its efforts to identify potentially relevant assets and ecosystems, Triodos examines prospective loan exposures with controversial data. The corporation utilized an own technology that is loaded with third-party controversy data from sources like RepRisk. This allowed for greater due diligence prior to engaging into a financing agreement, especially when there were violations of a set list of nature-related criteria, such as considerable and negative consequences on biodiversity, illegal logging, major water pollution, etc.

It also utilized ENCORE during the Locate phase to determine where the assets of its portfolio firms lie within regions of significant ground/surface water stress.

Gaps and challenges in the Locate stage

Consistently high-quality geospatial data is known to be challenging to get. Some companies may not be willing or able to give precise geographical data for their operations and supply chain. Organizations may be hesitant to publish geospatial data due to the assumption that it contains economically sensitive information or the fear that such publication might pose a security/reputational risk to assets and sites, such as those targeted by environmental activist organizations. In certain instances, organizational geographic data is not openly provided, but can be partially or completely deduced from publicly available internet information. These hurdles to disclosure remain a concern for both corporate and public organizations, where publication of geographic data is not seen to be in the public interest.

Moreover, geographical data encompassing the area of effect is highly preferred to enable high-quality evaluation and assessment, such as the identification of pertinent watersheds, intake streams, effluent sinks, and access routes, etc. In many cases, sourcing information beyond the location of operations is regarded as a significant challenge for users due to the following:

inconsistency in data quality and availability between geographies; a lack of data platforms that source and maintain spatial data at the watershed scale; and a lack of organizational resources to develop geospatial analysis and deliver ongoing monitoring and disclosure.

Where exact locations were unavailable, approximations were made using primary data to the national or regional level. For supply chains, input-output modelling was used as a high-level method to estimate the nation and industry of suppliers at each level of the supply chain, using data from sources such as Exiobase. However, in the absence of location data, input-output modeling can serve as a valuable starting point that can be refined over time using primary/secondary data. For certain firms, third-party data services might be utilized to confirm or fill in asset-level data gaps, however it is

acknowledged that all of these "gap filling" options offer limited consistency and accuracy.

Evaluate

Triodos categorized its investment portfolio and loan portfolio firms by subindustry in order to detect water-related dependency and impact concerns using the ENCORE instrument. Triodos assessed ground and surface water sources as 'very high' materiality dependencies for its food production exposures. The significance of water quality and water flow was rated as 'medium'. On the effect side, water usage and water pollutants were deemed to be of 'high' significance.

Triodos gathered original data directly from firms on water usage and replenishment, where possible, in order to comprehend the amount of dependence and potential magnitude of effect. This information was beneficial for both credit risk analysis and investment risk analysis.

Gaps and challenges in the Evaluate stage

Theoretically, expanded, primary data gathering at the asset, watershed, and ecosystem levels might yield higher-quality insights into the impacts of an organization. These main data may include water consumption, water chemistry, rates of biodiversity, watershed replenishment rate, yearly rainfall fluctuation, etc.

If these data are not already offered, it is not deemed viable or reasonable for an end user to get them without significant effort. As more businesses begin to evaluate and manage their dependencies and effects and share this information, users such as Triodos will be in a better position regarding the availability and quality of primary data. Secondary data can assist users in identifying pertinent nature-related effects and dependencies. Triodos might employ geospatial AI technologies, such as Rezatec's water SAT, to investigate water quality at various geographic scales. These insights can be used to fill data gaps (or validate datapoints), enhance corporate disclosures, or enable the aggregation of pertinent metrics across geographic regions and portfolios. When geographical data is approximated using country- or region-level data, the user's assurance regarding implications and risk is significantly reduced.

Some techniques measure the dependency of companies within a country on ecosystem services. Using the Biodiversity and Ecosystem Services Index (BES Index), which integrates data on water security, habitat integrity, water quality, erosion management, and coastal protection, among other metrics, CatNet® from Swiss Re enables evaluation of reliance materiality. This is an aggregated, top-down evaluation of risk that combines risk, loss, exposure, and corporate insurance information with selected geographic information (e.g., existing maps or satellite imagery) to provide a qualitative risk score. Investments may be aggregated by risk level and displayed as a proportion of the portfolio, which is important for users. Although the insights are confined to qualitative rating, these tools give a pragmatic method for finding meaningful impacts and connections in the absence of geographical data. Where controversy data identifies significant impacts in a company or its supply chain, credit officers or portfolio managers may request information from the companies/suppliers to demonstrate that this is adequately mitigated, e.g. evidence that the company/operations supplier's are not contributing to the controversy or impact, and/or information on how the impact and resulting risk is being managed and mitigated. Without this knowledge and active effort to control and reduce the impact, the motivation for corporations to operate or invest in places or industries with "high controversy" would remain low, and the impacts would endure. There is a danger that controversial data is taken as a full coverage of ESG concerns, but it is more likely to merely cover a selection of issues as reported by the media. Utilize controversial data in conjunction with other impact and dependence identification instruments. This problem is compounded in locations where media coverage of ESG concerns is inadequate, therefore these regions may appear to have disproportionately low effect and risk. Therefore, one should not rely on geographical comparisons to offer a thorough perspective of relative effect and risk. In response to concerns, users such as Triodos should investigate ways to support impact management and mitigation.

Assess

Triodos assessed the capacity of its firms to minimize the risks associated with the identified effects and dependencies in the Evaluate phase. Triodos evaluated the water-risk mitigation and management capabilities of each of its portfolio firms, beginning

with the highest-risk enterprises. Companies with relevant disclosures were evaluated using desk research. Triodos performed this personally but plans to outsource this evaluation in the future (which could be a bespoke assessment, or procurement of relevant data from a data provider, as new indicators and metrics come to market). Companies lacking pertinent disclosures may require more involvement to avoid classified as higher risk from a lending or investment standpoint. For instance, Triodos loans to the food production the company BioMooi.

BioMooi's facilities are located in an arid location. Triodos evaluated BioMooi's disclosures but requested more evidence that the company was addressing and minimizing physical hazards and transition risks, such as regulatory risks and reputational concerns:

• Physical risks: BioMooi provided Triodos with primary data, such as its operations' water footprint relative to total watershed demand, government-approved water management plans, certifications, and evidence of formal cooperation with other watershed users to monitor water demand and ensure source replenishment.

• Regulatory risks: BioMooi presented evidence of monitoring the risk of greater water regulation by authorities, such as an increase or introduction of water-taxes, by frequent government participation in operational areas.

• Reputational risks: BioMooi showed proof of evaluating water supply and demand from other water users, as well as active community participation on water shortage and quality problems.

Triodos was pleased that, despite BioMooi's location in a highly water-stressed zone that, according to forecasts, would continue to be water-stressed in the future, the company demonstrated adequate risk mitigation with regard to water reliance and impact risks. Triodos stipulated as a condition of its financing commitment that BioMooi commit to continuing involvement and monitoring of ESG problems and risk management.

Gaps and challenges in the Assess stage

Nature-related risks can spread further down the supply chain than a disclosure user like Triodos can see. Throughout the absence of reliable geolocation data and associated source data, these risks may exist in the supply chain and go unnoticed/unchallenged. Users should encourage and assist preparers in disclosing information about their suppliers and collaborating with them on nature-related risk and mitigation measures.

Triodos may depend on issue-specific or industry-specific certifications (such as International Water Stewardship Standard certification for water-related operations (AWS v2.0)) as an extra degree of assurance for mitigation action. Similarly, aggregations of data from all applicable certifications can provide a snapshot of the portfolio's risks and possibilities. In areas and businesses where certifications or internationally-recognized appropriate criteria may not exist, this creates a difficulty and eliminates this alternative. In addition, certificates may not always reflect industry best practices, may be fraudulent, or may be inaccessible to businesses for other reasons. Therefore, consumers should not rely on third-party certifications to give a full and comparable picture among preparers/portfolio firms, but rather should see them as only one of numerous information sources on mitigating activity.

Triodos may examine disclosures for specified action plans outlining how the firm expects to attain goals such as "nature-positive", including limiting water effects and dependencies, while requesting evidence from preparers on risk mitigation. It is recognized that preparers are not permitted to incorporate specific action plans in disclosures or other external publications. Without a strong ownership position or some type of operational/financial control, users may find it impossible to get this information, and their ability to interact actively with the preparer may be severely constrained. In these instances, users might collaborate to encourage portfolio firms to engage in nature-related risk and opportunity disclosure.

Prepare

Triodos categorized and assessed the risk profile of their exposures using the data and evaluations supplied by BioMooi and other firms. Triodos selected material/relevant risks for portfolio-level management and reporting to stakeholders.

Alignment of preparer disclosures enabled Triodos to capitalize on uniformity in the insights and analysis, allowing for comparisons across similar firms, and in certain instances provided decision-critical information. Triodos also developed a mitigation strategy for the identified threats and opportunities. This includes the selection of key performance indicators and discussion of how they would be evaluated over time to demonstrate success and risk minimization.

• Initially, the firm contemplated monitoring the share of its loan portfolio companies (operating assets and known supplier assets) that are located in biodiversity hotspots, UNESCO biospheres, RAMSAR wetlands, and other places of high ecological significance. To minimize the possible impact on nature and reputational damage to Triodos as an investor, it was believed that the proportion inside these regions should decrease over time (to zero, ultimately). It suggested to employ GIS shape data of these regions of interest (e.g., obtained via tools such as IBAT's "site of biodiversity value" and the UNESCO World Heritage geospatial data tool), overlayed with portfolio firm operating and supplier asset locations, when known, to monitor this. In addition, it monitored the extent of geospatial data supplied from portfolio firms and their suppliers, as opposed to third-party/gap-filling strategies. This should rise as primary data improves over time.

• Triodos explored monitoring the condition of freshwater habitats in the nations where its loan portfolio firms operate. It advocated using the Freshwater Ecosystems Explorer tool to annually check the status of reservoirs and water quality in these nations at the country level. When decreasing ecosystems are seen over a three-year period, portfolio businesses can develop/revise mitigation programs and raise the granularity of monitoring. Triodos consulted subject matter experts as part of its disclosure process to identify the 3-year timeline, but each user/preparer firm should evaluate its own timeframes depending on its own circumstances.

• Triodos also investigated, with regard to its investment portfolios, how it may begin to lessen the impact of its portfolio investments on water-related ecosystems. The baseline water footprint was calculated using accessible primary data (like BioMooi that reported this data to Triodos, above). Triodos assessed each portfolio company's water footprint based on multiregional input-output data where no water footprint data was available. Over time, the business will monitor the proportion of investments that submit primary water footprint data, with the goal of increasing this proportion and so improving accuracy. Triodos may utilize its stakes in such firms to push additional disclosures. This would also allow Triodos to monitor the water footprint reduction efforts of its portfolio firms (to the extent where reduced consumption is feasible; it also proposed to track water use relative to revenue, to monitor water footprint intensity over time).

The business wants to use this expanded water footprint statistics over time to gain a better understanding of the impact of mitigation activities made by portfolio companies, and to assess its own risk as an investor.

4 CONCLUSIONS

Banks influence biodiversity while also being vulnerable to the financial risks related to biodiversity degradation. Understanding the impact is the first step in managing it. Given that humans have already drastically altered 75% of the Earth's surface and that biodiversity loss is having a negative impact on 66% of the ocean area (Díaz et al., 2019). I hope that this study will help readers realize the necessity of taking action to limit biodiversity loss. By taking steps to begin tracking the biodiversity implications of their operations, banks can contribute to reducing biodiversity loss.

Through the lens of TNFD's beta risk assessment approach for nature-related risks and opportunities, the case study demonstrated the challenges, critical issues, and potential opportunities for data development:

• Lack of location-specific data for businesses. Banks and investment firms typically hold extensive instrument and ownership data models, but few/none hold asset location data;

• Lack of data that allows understanding of trends over time and predictions of nature-related impacts and dependencies in the future;

• Many questions related to methodology and exposure to specific data sources exist, lowering the confidence in the data and assessments provided by portfolio companies;

• Due to the complexity and multidimensionality of environmental consequences, portfolio-level reporting may be required at the sector, biome, or other level. Users are likely to define different priority metrics to meet their goals for rigor and aggregation, which is likely to result in an initial lack of comparability across users and a confusing set of expectations for issuers;
• Triodos has identified that preparers may also disclose to water-specific frameworks, such as CDP or Climate Disclosures Standard Board Water Guidance. Although potentially beneficial, this information was inconsistent among portfolio firms and may necessitate human review when evaluating investments.

Additionally, banks can contribute to the advancement of financial institutions' biodiversity policies by enhancing corporate biodiversity data transparency, developing suitable investment tools, ensuring methodological consistency in quantifying biodiversity benefits, and cooperating on these problems. Finally, banks might actively seek for funding for initiatives that promote biodiversity. The current trend of increasing biodiversity loss can be changed, and combined with conservation efforts, financing biodiversity projects may even be able to reverse this trend.

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Summary - *The impact on the financial risk of banks resulting from the loss of biodiversity and ecosystems.*

Ecosystem services are typically defined as the benefits humans receive from ecosystems (Boyd & Banzhaf, 2007; Costanza et al., 1997; Daily et al., 1997; Millennium Ecosystem Assessment, 2005; Fisher et al., 2009; TEEB, 2012; Costanza et al., 2017) and are categorized into four categories: provisioning, regulating, cultural, and supporting ecosystem services. Examples of each are timber and fish (provisioning), pollination (regulating), tourism-related coral reefs (cultural), and nutrient cycles (supporting) (Millennium Ecosystem Assessment, 2005; FAO, 2021b, 2021c, 2021d, 2021a). Ecosystem services are dependent on biodiversity and are thus closely related (Cambridge Conservation Initiative, 2020; De Nederlandsche Bank, 2020a; Hanson et al., 2012; United Nations, 1992; UNPRI, 2020; WWF, 2020). Therefore, this thesis utilizes the terms biodiversity and ecosystem services (BES) interchangeably. Businesses can benefit from ecosystem services through the facilitation of operations (such as crop pollination and predator and parasite control in ecosystems), the supply of raw materials (such as timber, wool, food, freshwater, and medicinal resources), water purification, and cultural services (such as contributions to education and tourism) (Millennium Ecosystem Assessment, 2005; FAO, 2021a, 2021b, 2021c, 2021d). Although it is difficult to quantify the value of ecosystem services (Newton et al., 2018), several studies have broken down the monetary values given by ecosystem services for various goods or industrial sectors. Examples include forest products such as timber and paper, which account for USD 247 billion of global trade exports (FAOSTAT-Forestry database, 2017); the pharmaceutical sector, where 25-50% of products are based on genetic compounds derived from nature (IPBES, 2019); the value of the global fishery sector, which is estimated to be worth USD 362 billion (FAO, 2018) or the value of soil biodiversity which is estimated to lie between USD 1.5 trillion to 13 trillion (Data European Soil Centre, 2021). According to Costanza et al., the yearly value of ecosystem services is between USD 125 trillion and USD 140 trillion (Costanza et al., 2014). Regarding inherent uncertainties, the study provides compelling evidence that people place a high monetary value on ecological

services. Constanza's 2014 estimates are comparable to a recent OECD report from 2019 and equal to 1.5 times the world GDP (OECD, 2019). More than half of the world's gross domestic product (USD 44 trillion) is moderately or strongly dependent on ecosystem services and natural capital assets, according to a World Economic Forum report (World Economic Forum, 2020b). However, at the risk of oversimplification, the continuous unsustainable economic expansion (both production and consumption patterns) of mankind, which is exacerbated by climate change, is causing the productivity of ecosystem services to decrease (Costanza & Daly, 1992; Millennium Ecosystem Assessment, 2005; Dasgupta, 2008; UNEP, 2016; Maxwell et al., 2016; van der Geest et al., 2019). While the global economy flourished between 1992 and 2014, as evidenced by a doubling of produced capital per person and a 13% growth in capital per person, studies indicate that the stock of natural capital per person has declined by 40% (Dasgupta et al., 2021). In 2005, the Millennium Ecosystem Assessment indicated that around sixty per cent of the twenty-four analyzed ecosystem services are deteriorated, whereas the only ones that have improved are directly related to our emphasis on food production, such as cattle or aquaculture (Millennium Ecosystem Assessment, 2005). And according to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), by 2019 humans would have changed 75% of the earth's land surface, destroyed 85% of all wetland habitats, and degraded more than 85% of the ocean (IPBES, 2019). Studies indicate that unsustainable economic expansion is not just exceedingly perilous for the vast majority of non-human life on earth, but that its influence on ecosystem services will also have serious consequences for our way of life, particularly our economy (TEEB, 2010). In their study, Costanza et al. (2014) projected that between 1997 and 2011, biodiversity loss and ecosystem degradation cost the world economy between USD 4.3 trillion and USD 20.2 trillion (Costanza et al., 2014). If a business-as-usual scenario leads to a reduction in the supply of six ecosystem services (pollination of crops, protection of coasts from flooding and erosion, supply of water, timber production, marine fisheries, and carbon storage), the global GDP could decline by 0.67 per cent per year until 2050 (Roxburgh et al., 2020). In terms of specific ecosystem services, examples include: pollinator loss puts USD 400 billion of global crop output at risk, overexploitation of fishing grounds costs USD 50 billion annually (IPBES, 2019), and land degradation

can have significant effects on the ecosystem service value (ESV) of many nations (Kertész, 2017). China is anticipated to lose 6.6% of ESVs annually, Russia 7.4%, the United States 8%, and India 20.3%. (Sutton et al., 2016). Globally, land degradation has lowered the ESV by USD 6,3 trillion per year (Sutton et al., 2016). Furthermore, land deterioration is not the sole threat. For instance, the World Economic Forum identifies biodiversity loss and its effect on ecosystem service as one of the most consequential and probable global hazards for 2020 (World Economic Forum, 2020a). This extinction has a negative influence on the advantages that humans derive from ecosystems (Cardinale et al., 2012; Hooper et al., 2012). As the negative effects of ecological degradation and the resulting economic repercussions increase, it is reasonable to inquire about the implications for financial institutions such as banks. In the European Union, financial institutions are classified as monetary financial institutions, investment funds, financial vehicle corporations, institutions related to payment statistics, insurance corporations, and pension funds (European Central Bank, 2021c). In this definition, credit institutions (used as a synonym for banks) (De Nederlandsche Bank, 2021), which are monetary financial institutions, are described as "an enterprise whose business is to accept deposits or other repayable money from the general public and provide credits for its account" (European Banking Authority, 2019, 2020). In other words, one of the fundamental activities of banks is characterized as the supply of finance and lending solutions to the company (Allen et al., 2014). If ecosystems are degraded and firms are exposed to dangers, then financial institutions such as banks may also be harmed (OECD, 2019). This thesis will concentrate on banks to illustrate a significant subset of financial entities.

The primary threats to biodiversity and ecosystem services (BES) faced by financial institutions are physical and transitional (Cambridge Centre for Sustainable Finance, 2016; G20 Green Finance Study Group, 2017; NGFS, 2020). These two environmental risks can then result in the following financial risks: (i) credit risk (default of credit), (ii) market risk (declining value of assets), (iii) underwriting risk (increasing insurance gap and increasing insurer losses), (iv) operational risk (disruptions to the supply chain or other operations), and (v) liquidity risk (increasing demand for capital) (Cambridge Centre for Sustainable Finance, 2016; G20 Green Finance Study Group, 2017; NGFS, 2020). As seen by the development of efforts such as the Network of Central Banks and

Supervisors for Greening the Financial System (NGFS) and the Taskforce for Nature-related Financial Disclosure (TNFD), there has been a recent increase in awareness in the financial industry. The EU Taxonomy law outlines six environmental objectives for the EU policy agenda, one of which is "the conservation and restoration of biodiversity and ecosystems" (Regulation (EU) 2020/852, 2020). Lastly, financial institutions do independent research, such as the Dutch Central Bank, ASN Bank, and CDC Biodiversity. For instance, in the framework of this argument, equity investments of financial institutions in the Netherlands totalling EUR 510 billion are highly or very highly dependent on ecosystem services (De Nederlandsche Bank, 2020a). In 2019, the world's 50 largest banks are supporting enterprises that exacerbate climate and biodiversity issues, according to separate research (Portfolio Earth, 2020). However, these estimates may represent just a portion of the actual risk that exists. In 2018, the 6,088 credit institutions in Europe possess assets totalling 43.35 trillion euros (European Banking Federation, 2020a). And by the end of 2020, the 112 major banks monitored by the European Central Bank (ECB) would possess assets totalling EUR 24,1 trillion. This consisted of 5 trillion euros in loans to non-financial corporations and 2,9 trillion euros in debt securities, including equity holdings (European Central Bank, 2020a, 2021a). As financial institutions adhere to the basic "risk/return" ratio, a greater awareness of the true effect of environmental hazards and dependencies and the internalization of this information into the "risk/return" ratio might result in a shift in investments (Suttor-Sore, 2019). As a result, it is in the best interest of the financial industry and banks to include environmental risks effectively, as a lack of awareness of any risks can result in the accumulation of threats and the allocation of resources to higher-risk activities. Failure to do so might threaten the long-term stability of our economy (Cambridge Centre for Sustainable Finance, 2016). Financial institutions may play a crucial role in mitigating the global economic hazards of BES loss if they comprehend the dangers and act on them more aggressively than they do now (ShareAction, 2020; TEEB, 2010). Long-term neglect of environmental risks can lead to the emergence of systemic risks that wreak havoc on the financial sector and the broader economy (Monnin, 2018).

PURPOSE AND OBJECTIVES

This research seeks to investigate the impact of the financial risk posed by the loss of biodiversity and ecosystem services on banks.

Through a review of current literature, it was determined how the loss of biodiversity and ecosystems translates into a serious danger for the financial sector, with an emphasis on banks.

After investigating the aforementioned, it was determined how banks' approach to this type of risk is evolving, shifting from an approach based on the simple analysis and integration of risks arising from the loss of biodiversity and ecosystems to a step forward, encompassing the allocation of credit to promote and accelerate the green transition.

As a final component of the literature analysis, we investigated ways to assess the likelihood that biodiversity loss and the measures taken to fight it provide financial risks that undermine the stability of individual financial institutions and the financial system as a whole.

Following a review of the relevant literature, a case study approach was adopted to investigate current challenges and future priorities in the landscape of nature data in order to explore challenges, key issues, and potential opportunities for data development through the lens of the TNFD beta assessment process for nature-related risks and opportunities.

METHODOLOGY

Data and analytics availability and capability are critical success factors for the achievement of the TNFD's goal to provide organisations with a framework to report on the risks arising from biodiversity loss and ecosystem degradation. Improved data and information availability will enable organizations to integrate these risks more accurately and reliably into decision making. As the Dasgupta Review on the Economics of Biodiversity highlighted, standardised, credible, decision-useful data is required to underpin global standards that enable companies and financial institutions to report and act on nature-related risks and opportunities. Data availability, quality and ease of use will be driven by:

- the development of metrics and indicators;
- the growing adoption of nature-related targets in corporate strategy and reporting; and
- innovation of new tools, services and capabilities.

To explore current challenges and future priorities in the nature-related data landscape, this section has adopted a case study approach. The following case study explore challenges, key issues and potential data development opportunities through the lens of the TNFD's beta risk assessment process for nature-related risks and opportunities, known as LEAP.

INTRODUCTION TO THE TNFD NATURE-RELATED RISK AND OPPORTUNITY ASSESSMENT APPROACH: LEAP

Since the launch of the TNFD, market participants have indicated that simple, accessible guidance on how to understand and respond to nature-related risks and opportunities would be a welcome complement to a set of disclosure recommendations. In response, the TNFD has developed an integrated assessment process for nature-related risk and opportunity management called LEAP.

- Locate your interface with nature;
- Evaluate your dependencies and impacts;
- Assess your risks and opportunities; and
- Prepare to respond to nature-related risks and opportunities and report.

Figure 3: LEAP Methodology

Source: (TNFD) Task force on Nature-related Financial Disclosures' website

The LEAP approach is voluntary guidance intended to support internal, nature-related risk and opportunity assessments within corporates and financial institutions to inform strategy, governance, capital allocation and risk management decisions, including disclosure decisions consistent with the TNFD's draft disclosure recommendations.

LEAP has been designed and developed with three overarching considerations in mind:

- The LEAP approach encourages users to carefully consider the scope of their assessment before commencing;
- Analysts and preparers are encouraged to consult with relevant stakeholders as they work their way through the LEAP approach; and
- LEAP is designed as an iterative process – across business locations, business lines for corporates, and across investment portfolios and asset classes for financial institutions – in line with enterprise risk management processes and reporting and disclosure cycles.

This early prototype of LEAP has been designed as a general approach for use by a wide range of corporates and financial institutions. The TNFD recognizes that a general approach is difficult to develop, given variations in business models, sector-based market dynamics and the information needs of users. Financial institutions, in particular, have different decision making and information requirements to corporates; and there is significant difference among financial institutions.

The TNFD also recognises that some organisations may already have an equivalent process built into their enterprise risk management framework. In such cases, the LEAP approach can be used as a checklist to ensure existing internal processes adequately address nature-related risks and opportunities.

Finally, in developing the LEAP approach, the Taskforce has built on and integrated existing, high-quality nature-related frameworks, tools, data sources and other guidance developed by a range of other organizations that are aligned with the TNFD's principles and approach. The source frameworks and tools used are signposted throughout the phases of the LEAP approach, with descriptions of how they may be used by organisations. As new frameworks, tools, data sources and guidance are developed, the TNFD will add additional signposts into the LEAP approach.

SELECTION OF THE BANK FOR THE CASE STUDY

A combination of reasons influenced the final selection of the bank to be examined as a case study in this thesis.

During 2022, I had the opportunity to work as ‘ESG Junior Consultant’ at the consulting firm "PwC Italy," where owing to the different workshops offered by the company, I was able to interact with the bank's sustainability-focused associates.

I was able to interact personally with the associates during the meetings in which the bank's internal processes were presented in order to appropriately address the risks and opportunities related to nature. This allowed me to collect all the additional information necessary to perform the case study.

In addition to the luck of being able to interact with experts in the field of interest, the choice of a purely Dutch bank comes in part from my Dutch Erasmus experience at the renowned University of Maastricht (School of Business and Economics) during the academic year 2021-2022, where some topics on nature-related risks and opportunities were already being examined, which led me to realize that the Netherlands is one of the most environmentally conscious nations in the world. Indeed, De Nederlandsche Bank (DNB) was the first central bank to quantify the extent to which the financial institutions it controls are exposed to risks from biodiversity loss (van Toor et al., 2020). It was determined that 36% of Dutch financial institutions' investments are highly or extremely dependent on one or more ecosystem services. Ecosystems that offer both groundwater and surface water exhibited the greatest dependence.

In this regard, Triodos Bank was chosen, which is a bank with a strong focus on financing the Food and Agribusiness (F&A) sector, its concerned that the sector - and thus its exposures to companies in the sector - may be exposed to a high level of nature-related risk, specifically in relation to water issues.

TRIODOS BANK

Triodos Bank N.V. is a bank based in the Netherlands with branches in Belgium, Germany, United Kingdom and Spain. It was founded in 1980 and as of 2021, Triodos Bank has over 750,000 customers worldwide. Triodos Bank finances companies which it believes add cultural value and benefit to both people and the environment. To evaluate its exposure, Triodos carried out its own assessment to identify key risks and opportunities associated with its different exposures to food manufacturing companies.

CONCLUSIONS

Banks influence biodiversity while also being vulnerable to the financial risks related to biodiversity degradation. Understanding the impact is the first step in managing it. Given that humans have already drastically altered 75% of the Earth's surface and that biodiversity loss is having a negative impact on 66% of the ocean area (Díaz et al., 2019). I hope that this study will help readers realize the necessity of taking action to limit biodiversity loss. By taking steps to begin tracking the biodiversity implications of their operations, banks can contribute to reducing biodiversity loss.

Through the lens of TNFD's beta risk assessment approach for nature-related risks and opportunities, the case study demonstrated the challenges, critical issues, and potential opportunities for data development:

• Lack of location-specific data for businesses. Banks and investment firms typically hold extensive instrument and ownership data models, but few/none hold asset location data;

• Lack of data that allows understanding of trends over time and predictions of nature-related impacts and dependencies in the future;

• Many questions related to methodology and exposure to specific data sources exist, lowering the confidence in the data and assessments provided by portfolio companies;

• Due to the complexity and multidimensionality of environmental consequences, portfolio-level reporting may be required at the sector, biome, or other level. Users are likely to define different priority metrics to meet their goals for rigor and aggregation, which is likely to result in an initial lack of comparability across users and a confusing set of expectations for issuers;
• Triodos has identified that preparers may also disclose to water-specific frameworks, such as CDP or Climate Disclosures Standard Board Water Guidance. Although potentially beneficial, this information was inconsistent among portfolio firms and may necessitate human review when evaluating investments.

Additionally, banks can contribute to the advancement of financial institutions' biodiversity policies by enhancing corporate biodiversity data transparency, developing suitable investment tools, ensuring methodological consistency in quantifying biodiversity benefits, and cooperating on these problems. Finally, banks might actively seek for funding for initiatives that promote biodiversity. The current trend of increasing biodiversity loss can be changed, and combined with conservation efforts, financing biodiversity projects may even be able to reverse this trend.