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Biodiversity-related Financial Risks – why it matters and how can we measure them?

Case study of Georgia

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Abstract

The potential consequences of biodiversity and ecosystem services loss can have a significant impact on the stability of economies and financial systems. The following research paper contributes to a growing body of literature that seeks to analyze the connections between biodiversity loss and financial stability. The study focuses on the assessment of biodiversity-related financial risks (BRFR) in Georgia and provides quantitative estimates of the dependencies and impacts of the financial system on biodiversity and ecosystem services. The findings reveal that around 46 percent of Georgian commercial banks' lending portfolio to legal entities could be exposed to biodiversity-related physical risk, being moderately or highly/very highly dependent on one or more ecosystem services. Additionally, around 54 percent of Georgian banks' business lending portfolio could be exposed to sectors that strongly impact ecosystem services and, thus, may face a high transition risk.

JEL Codes: E58, G21, Q01, Q57

Keywords: Biodiversity; Biodiversity-related Financial Risks; Ecosystem Services, ENCORE

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Content

List of Diagrams

List of Tables

Introduction

Biodiversity[i] enables the natural world to be productive, resilient and adaptable, it is also responsible for underpinning the ecosystem services (ESs) that are vital for the functioning of the global economy.[3] An alarming rate of biodiversity loss threatens the functioning of natural ecosystems and creates significant material risks for real economy and financial sector.[4] According to the World Bank (WB) study[5], in a worst-case scenario of partial ecosystem collapse, world could experience around 10 percent lower global real gross domestic product (GDP) growth from 2021 to 2030 compared to the baseline scenario, according to which no ecological tipping points are reached. Relative impacts potentially can be more pronounced in low-income and lower-middle-income countries. As a result, it is crucial to identify and measure biodiversity-related financial risks (BRFR) to mitigate their potential impact on financial stability.

This paper examines the importance of biodiversity for the economy and financial systems, the potential financial risks associated with biodiversity loss, and the challenges of measuring these risks. The case study of Georgia is used to illustrate the practical application of these concepts.

Biodiversity loss can lead to financial risks through several channels, including direct impacts on businesses, such as decreased productivity and increased operational costs, and indirect impacts on financial institutions, such as reduced asset values and increased credit risks. These types of the risks can affect various economic sectors, including agriculture, fisheries, tourism, and pharmaceuticals. Hence, BRFR require a comprehensive valuation for a better understanding of the impacts and dependencies of financial institutions on biodiversity and ecosystems.

Among the factors contributing to the biodiversity loss, is one prominent factor - climate change, which is both driven by and amplified by nature[ii] loss.[6] Thus, the risks posed by biodiversity and ecosystem services (BES) loss threaten environmental, social, and economic systems, and in addition, are interacting with climate change risks in a vicious circle.[7][8]

Identifying and measuring biodiversity-related financial risks is a challenging task due to limited data and methodological uncertainties. Apart from that there exist numerous challenges related to biodiversity and ecosystem services (BES) valuation, including the non-linearity of natural processes, the limited substitutability of natural capital assets, the uncertainty of the timing and severity of impacts, and absence of unequivocal metric. However, recent advances in measuring biodiversity and its economic value, along with the development of biodiversity-related financial instruments, provide new opportunities to address these challenges. And this paper constitutes a first step towards assessing the exposure of the Georgian financial system to BRFR.

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[3] Dasgupta, Partha. "The Economics of Biodiversity The Dasgupta Review Abridged Version". (2021).

[4] Dikau, Simon. "NGFS Occasional Paper-Biodiversity and financial stability: exploring the case for action". (2021).

[5] Johnson, Justin Andrew, Giovanni Ruta, Uris Baldos et al. "The Economic Case for Nature." (2021).

[6] McElwee, Pamela. "Climate Change and Biodiversity Loss: Two Sides of the Same Coin". (2021).

[7] Kedward, Katie, Josh Ryan-Collins, Hugues Chenet. "Biodiversity loss and climate change interactions: financial stability implications for central banks and financial supervisors". (2022).

[8] Bradshaw, Corey JA, Paul R. Ehrlich et al. "Underestimating the challenges of avoiding a ghastly future". (2021).

The case study of Georgia highlights the importance of biodiversity for the country's economy and the potential financial risks associated with biodiversity loss. The paper proposes a methodology to measure biodiversity-related financial risks in Georgia and provides recommendations for policymakers and financial institutions to integrate biodiversity considerations into financial decision-making processes.

The research on BFRF is crucial for prudential oversight. It might enable the identification and mitigation of emerging risks in the loan portfolios and investments of commercial banks in Georgia. The main objectives of the paper are to: (i) overview the transmission channels of BRFR to the financial system; (ii) assess BRFR physical and transition risks of the Georgian financial system; (iii) contribute to the growing research literature.

The paper is organized as follows: the second section overviews the transmission channels of BRFR and how it affects economy and financial system. The next section represents the literature review on research undertaken worldwide in assessing BRFR. The fourth section overviews the condition and importance of BES in Georgia. The following section describes the methodology used in the paper and provides the main research results. The last section provides key findings and discusses the avenues for future research.

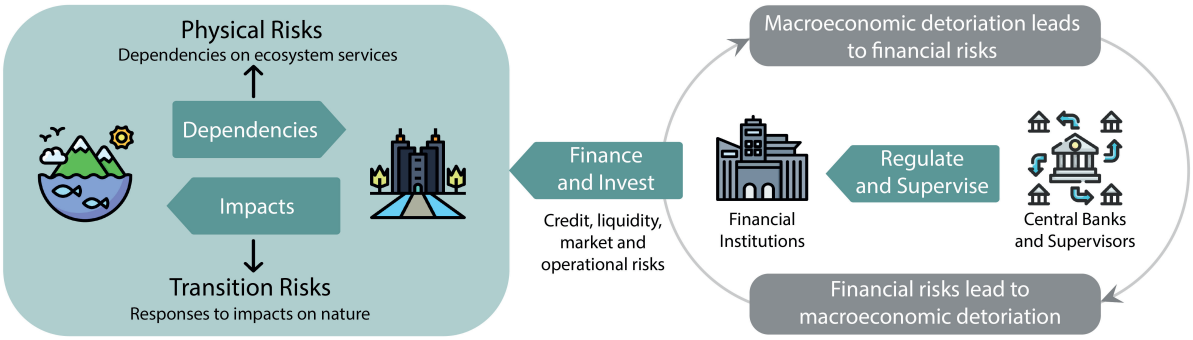
Biodiversity Loss – why it matters for the economy and financial stability

According to the World Economic Forum (WEF) latest Global Risks Report (2023),[9] biodiversity loss and ecosystem collapse is viewed as one of the fastest growing global risks over the next decade. All real economic activities both depend on and affect nature (see Diagram 1). It is estimated that roughly, over half of global GDP is highly or moderately dependent on nature and ecosystem services[10], and an alarming rate of biodiversity loss can cause the collapse of ESs in the fifth of the world countries.[11]

Anthropogenic activities have a profound and sometimes permanent effect on biodiversity, leading to negative impacts on ESs. The ESs are the benefits ecosystems provide to maintain life and well-being. There are four main categories of ESs: supporting services (such as decomposition that helps maintain soil fertility), provisioning services (such as food from plants, animals, and microorganisms), regulating services (such as trees and plants controlling the climate through greenhouse gas storage), and cultural services (such as recreation and ecotourism).[12]

[9] WEF. "Global Risks Report 2023". (2023).
[10] WEF and PwC. "Nature risk rising: Why the crisis engulfing nature matters for business and the economy". (2020).
[11] Re, Swiss. "Biodiversity and Ecosystem Services A business case for re/insurance". (2020).
[12] TEEB, Recommendations of "Mainstreaming the Economics of Nature". (2010).

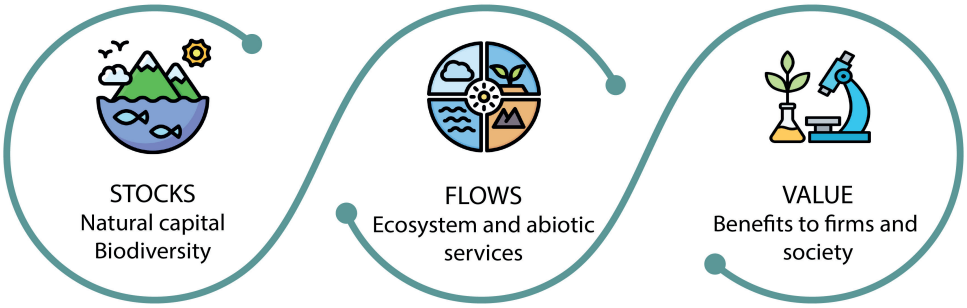
Diagram 1. Impacts and dependencies of real economy and financial sector on biodiversity and ecosystem services



Source: Adapted from Almeida and Dikau (2022)

Companies, industries, and sectors as well as humans directly or indirectly depend upon the ecosystem services flowing from the stocks of renewable and non-renewable natural resources that maintain life on earth (Diagram 2). One of the examples of direct dependence on BES is common agricultural practice – crop production, where yield is determined by pollination.[13] Additionally, there are also indirect dependencies through the supply chain where downstream industries, such as food processing or textile manufacturing, rely on a steady supply of food, fibers, and other natural resources from upstream sectors, making them indirectly dependent on BES. Any disturbance in the upstream sector like poor harvest can result in unstable raw material prices, causing harm to the downstream industries.[14]

Diagram 2. Biodiversity, ecosystem and abiotic services and benefits to business and to society



Source: Adapted from Natural Capital Coalition (2016)

On the impact side, real economy activities affect natural capital and biodiversity through either inputs (changes in land and sea use or exploitation of natural resources) or outputs (waste, emissions

[13] Fijen, Thijs PM, Jeroen A. Scheper et al. "Insect pollination is at least as important for marketable crop yield as plant quality in a seed crop."(2018).

[14] CISL. "Handbook for nature-related financial risks: Key concepts and a framework for identification". (2021).

and pollution). Such impacts on natural capital and biodiversity in turn influence nature's ability to provide ecosystem services and therefore trigger significant disruptions to economic production.[15]

According to the Global Futures Report (2020), if biodiversity loss continues at its current trajectory it will result in a loss of US$ 10 trillion in global GDP between 2011 and 2050. [16] Alongside, the evidence from the Paulson Institute Financing Nature Report (2020) suggests that to reverse this decline by 2030, spending of between US$ 722-967 billion is required globally each year over the next ten years. [17] While there exist multiple challenges associated with the calculations of the total value of biodiversity, it can be concluded that its collapse might threaten the real economy through three main channels[18]:

I. ***Supply shocks***. Since companies of all sizes are directly or indirectly dependent upon ecosystem services, the loss of BES may result in acute and chronic effects. For example, increased vulnerabilities in global food provisioning systems[iii,iv] can lead to an increased likelihood of adverse supply shocks, resulting in sudden upward spikes in prices. Food supply shocks are increasing worldwide[19,20], particularly the type of shock wherein food production or distribution loss in one location propagates through the food supply chain to other locations.[21]
II. ***Demand shocks.*** Since particular companies have potentially large negative impacts on nature, they might face possible demand shocks resulting from changing consumer preferences and in technology-push and demand-pull regulatory policies[v]. In addition, compliance with growing environmental standards and consumers' pressure often involves additional capital or operational expenditures. Otherwise, such companies may be the subject to reputational risks and exit the market.
III. ***Systemic shocks.*** Accelerating rate of biodiversity loss might give rise to second- and third-order effects, which may affect companies further down the supply chain and even lead to the extinction of a certain number of economic activities due to the depletion of particular ecosystem services. As evidenced by the Covid-19 pandemic, addressing crises stemming from disruption in production and supply chains due to can have complex and significant consequences for the global economy.[22] For exposed companies, supply disruption and shift in demand and preferences might translate into significant material financial impacts, such

[15] NCFA and UNEP WCMC. "Exploring Natural Capital Opportunities, Risks and Exposure: A Practical guide for financial institutions". (2018)
[16] Johnson, Justin Andrew, Uris Lantz Baldos, Thomas Hertel et al. "Global futures: Modelling the global economic impacts of environmental change to support policy-making". (2020).
[17] Deutz, Andrew, Geoffrey M. Heal et al. "Financing nature: Closing the global biodiversity financing gap."(2020).
[18] Kedward, Katie, Josh Ryan-Collins, and Hugues Chenet. "Managing nature-related financial risks: a precautionary policy approach for central banks and financial supervisors". (2020).
[19] Cottrell, Richard S., Kirsty L. et al. "Food production shocks across land and sea" (2019).
[20] Wenz, Leonie, and Anders Levermann. "Enhanced economic connectivity to foster heat stress–related losses." (2016).
[21] Tu, Chengyi, Samir Suweis, and Paolo D'Odorico. "Impact of globalization on the resilience and sustainability of natural resources." (2019).
[22] Lebastard, Laura, and Roberta Serafini. "Understanding the impact of COVID-19 supply disruptions on exporters in global value chains." (2023).

as increased cost of capital, stricter borrowing requirements, stranded assets, increased risk of default and changes to firm market valuation.[23]

Biodiversity loss creates threats to not only companies and private sector; it poses risks to households as well as to the public sector. Moreover, it also might include sovereign-level risks that could impair the ability of countries to manage their fiscal operations[24,25], including the long-term servicing of debt and creditworthiness, and monetary operations, such as shocks to exchange rates and volatile commodity prices.[26,27] Therefore, current decline and potential further degradation of biodiversity and ecosystem services create threats to financial stability.[28]

By financing the real economy, financial institutions are exposed to the dependencies and impacts of companies on biodiversity and ecosystem services and thus, are accountable for facilitating negative impacts.[29,vi] Financial activities are vulnerable to both biodiversity-related physical and transition risks. These risks arise from the dependency of companies on ecosystem services and/or from their negative impact on biodiversity.

The combination of physical and transition risks may result in systemic risks that could emerge in various forms, causing a natural system to collapse in the medium to long term, sometimes even permanently. Therefore, BRFR risks may pose potentially systemic threats to financial stability, affecting all sectors globally.[30,31] Biodiversity loss can affect financial assets, institutions, and systems through multiple impact channels that arise from physical and transition risks (see Diagram 3).

[23] McCraine, S., C. Anderson, C. Weber, M. R. Shaw. "The nature of risk: A framework for understanding nature-related risk to business." (2019).

[24] Agarwala, Matthew, Matt Burke, Patrycja Klusak et al.. "Nature Loss and Sovereign Credit Ratings." (2022)

[25] Pierre Monin (2022). "Monetary policy operations and biodiversity loss".

[26] Pinzon, Alexandra, Nick Robins, M. McLuckie et al. "The Sovereign Transition to Sustainability. Understanding the Dependence of Sovereign Debt on Nature". (2020).

[27] Rudgley, Grant, Nina Seega. "Handbook for Nature-related Financial Risks: Key concepts and a framework for identification". (2021).

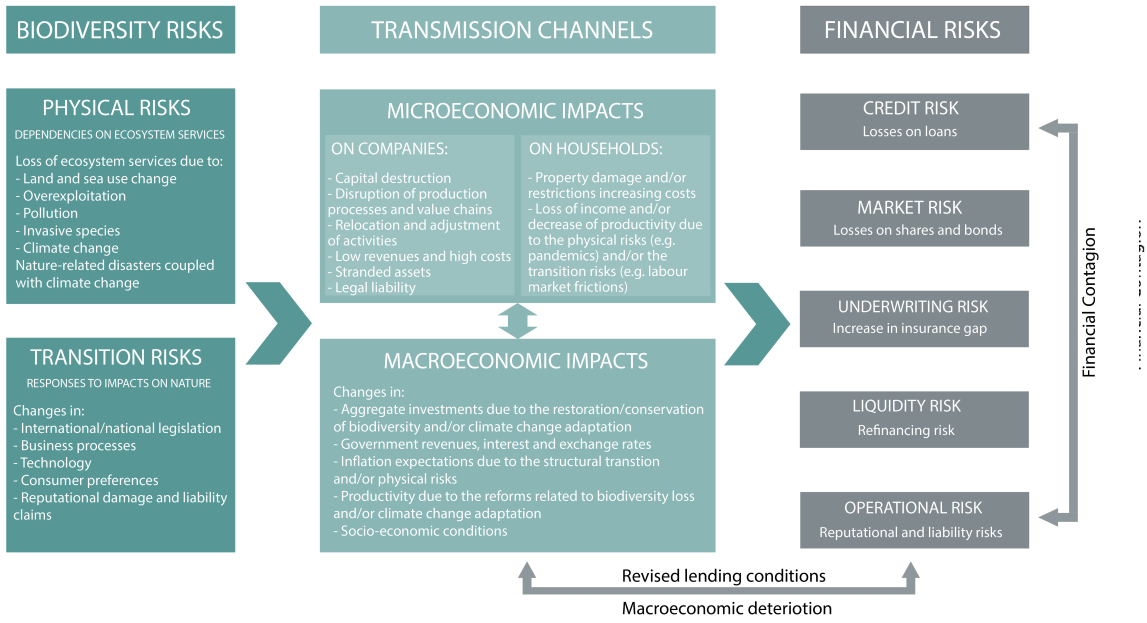
[28] Bosch, R. Ripoll. "Central banking and supervision in the biosphere: An agenda for action on biodiversity loss, financial risk and system stability: Final Report of the NGFS-INSPIRE Study Group on Biodiversity and Financial Stability". (2022).

[29] NGFS. "Guide for Supervisors: Integrating Climate-Related and Environmental Risks into Prudential Supervision." (2020).

[30] Bolton, Patrick, Morgan Despres et al. "The green swan." (2020).

[31] Canopy, Global, and Vivid Economics. "The Case for a Task Force on Nature-related Financial Disclosures." (2020).

Diagram 3. Transmission channels of biodiversity-related financial risks



Source: Adapted from NGFS (2020c), van Toor (2020), Svartzman et al., (2021)

Physical risks stem from the dependencies of economic activities on natural capital assets and ecosystem services and therefore, are primarily result from the five direct drivers of biodiversity loss[vii]: climate change, invasive species, land and sea use change, overexploitation of natural resources and pollution. On the other hand, indirect drivers related to demographic, socio-economic, technological, institutional, and governance trends in human societies influence these direct drivers. [32]

The physical risks can be chronic (e.g., the use of pesticides contributing to a decline of pollinators resulting in reducing crop yields[viii], a decrease in soil fertility due to the decline of microorganisms[33]), or acute (e.g., pandemics). Physical risks can mainly be characterized by operational nature, relating to resource dependency, scarcity and quality and tend to occur at local level.[34] However, they might have potential to quickly spread on multiple sectors and occur at an international level (e.g., disruption of global supply chains). The financial sector is exposed indirectly to physical risks by providing lending, investing and advisory activities to companies whose production processes depend on ecosystem services and contributes to the biodiversity loss. For the financial institutions, physical risks mainly represent the market and credit risks and thus, threaten the financial stability. [35]

[32] Diaz, Sandra Myrna, Josef Settele et al. "The global assessment report on biodiversity and ecosystem services: Summary for policy makers." (2019).
[33] Bastida, Felipe, A. Zsolnay, Teresa Hernández, and Carlos García. "Past, present and future of soil quality indices: a biological perspective." (2008).
[34] Esposito, Stefano. "Bringing it Down to Earth: Nature Risk and Agriculture." (2021).
[35] World Economic Forum (WEF). "The Global Risks Report 2020". (2020).

Financial institutions are also indirectly exposed to transition risks through their activities (lending, investing and advisory).

Transition risks stem from the efforts to conserve biodiversity and restore functioning of ecosystem services, and emerge in case, if the activities of financial institutions become inconsistent with new or tightened regulation and policies, rapid changes in consumer preferences and/or technological developments. Transition risks might occur on local (changes in the national legislation) or on the international (changes in global trade agreements) levels.

From the perspective of financial institutions, transition risks entail the probability of default on loans, lower investment profitability (or even write-downs on investments) and stranded assets in companies with production processes that have a negative impact on biodiversity. Significant credit, market and litigation risks can create additional challenges for financial institutions to obtain refinancing in the short term and thus, generate the liquidity risks. Furthermore, physical and transition risks could merge, and multiple contagion channels could appear between different financial risks ("financial contagion" arrow in Diagram 3), with potential feedback loops on the economic system.[36]

Thus, the loss of biodiversity poses potentially serious concerns to financial stability and economic performance in two main ways. First, the ecosystem services underpinned by biodiversity and other abiotic natural resources are critical to economic activity and financial assets, which on the other hand, increases the possibility of physical risks to finance if these services are compromised. Second, the shift to a nature-positive global economy poses transition risks since economic activity and financial assets have an impact on biodiversity and nature.[37] It is also shown on Diagram 3 how macroeconomic deterioration leads to increased financial risks and vice-versa - financial risks lead to macroeconomic deterioration. Table 1 summarizes examples of BFRF as drivers of prudential risk categories and how the contagion can escalate through the financial system.

Additionally, systemic risk might occur if any of the above listed risks hit a wide range of companies or projects simultaneously. The COVID-19 pandemic can be used as an illustrative example of a systemic biodiversity-related risk, as the habitat loss and fragmentation increase the probability of transmission of viruses from animals to humans.[38,39]

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[36] Svartzman, Romain, Etienne Espagne, Gauthey Julien et al. "A'Silent Spring'for the Financial System? Exploring Biodiversity-Related Financial Risks in France." (2021).

[37] Bosch, R. Ripoll. "Central banking and supervision in the biosphere: An agenda for action on biodiversity loss, financial risk and system stability: Final Report of the NGFS-INSPIRE Study Group on Biodiversity and Financial Stability". (2022).

[38] Xiao, Kangpeng, Junqiong Zhai, Yaoyu Feng et al. "Isolation and characterization of 2019-nCoV-like coronavirus from Malayan pangolins." (2020).

[39] Zhou, Peng, Xing-Lou Yang, Xian-Guang Wang et al. "A pneumonia outbreak associated with a new coronavirus of probable bat origin." (2020).

Table 1. Biodiversity-related financial risks as drivers of prudential risk categories

Risk type	Potential effects of ecosystems services and biodiversity loss	Examples of physical and transition biodiversity – related financial risks affecting prudential risks
Credit risk (losses on loans)	The loss of soil fertility, pollination, and natural pest control ecosystem services contribute to the lower crop yields and other in disruptions in production[40]. This can increase the probability of default of the company. The loss of ecosystem services can affect the resilience of the natural systems to severe natural disasters[ix] (for example, floods[41]), and therefore result in higher infrastructure damages, which on the other hand can lower the collateral values.[42]	Revaluation of debt-servicing capacity and collateral. Cumulative long-term increase in corporate nonperforming loans (NPLs).
Market risk (losses on the shares and bonds)	The introduction of the new and stricter biodiversity-related policies and regulations could lead to re-pricing of financial instruments, resulting in the decline of the market value of securities held on financial institutions' balance sheets. The introduction and/or expansion of new protected areas can result in stranded assets.[43] [44]	Rating downgrades and share price losses after biodiversity loss. Stranded assets
Insurance risk (increase in insured losses and in insurance gap)	The higher insurance premiums from biodiversity loss (e.g. coral reefs in Cancun, Mexico), insurance claims or lower returns on investments caused by severe natural disasters and extreme weather events worsened by degradation of environment.	Increased insurance claims Increased insurance premiums
Liquidity risk (shortages of liquid assets, refinancing risk)	The access to stable sources of funding could be reduced as market conditions change. Substantial credit, market and litigation risks can additionally make it more difficult for financial institutions to obtain refinancing in the short-term.	Withdrawal of deposits and credit lines Challenges with the obtaining the refinancing in the short-term
Operational risk (liability risks, reputational damage, legal risks)	Natural hazards can affect financial institutions' business continuity through, for example, affecting critical functions of the financial entity or of its main providers. Furthermore, liability claims or reputational damage can lead to higher operational risks. Being affiliated with financing the major destructive environmental events, such as oil spills[45] or deforestation may lead to liability charges and reputational damage. In addition, reputational damage to companies can translate into credit and market risks for financial institutions.	The losses on balance sheet Image loss resulting from failure to switch to biodiversity management

Source: Adapted from BaFin (2019), van Toor (2020), Svartzman et al., (2021)

[40] Diaz, et al. "The global assessment report on biodiversity and ecosystem services: Summary for policy makers." (2019).
[41] Forest Research. Cases for and against forestry reducing flooding. Forest Research: Publications and Research. (2022).
[42] Canopy, Global, and UNEP-FI. "Beyond 'Business as Usual': Biodiversity Targets and Finance." (2020).
[43] Suttor-Sorel, Ludovic. "Making Finance Serve Nature." Finance Watch (2019).
[44] Regelink, Martijn, Henk Jan Reinders, Maarten Vleeschhouwer, and Iris van de Wiel. "Waterproof? An exploration of climate-related risks for the Dutch financial sector." (2017)
[45] Reuters. BP Deepwater Horizon costs balloon to $65 billion. 16 January 2018.

Assessing Biodiversity-related Financial Risks - Literature Review

Recognizing the materiality of the BRFR, growing number of central banks have started to assess the dependencies and impacts of financial systems on biodiversity and ecosystem services.

One of the first central banks, which attempted to assess the BRFR was the central bank of the Netherlands - De Nederlandsche Bank (DNB)[46]. In particular, van Toor et al. (2020) provided the first comprehensive national assessment of how Dutch financial institutions are exposed to physical and transition risks related to ecosystem degradation and biodiversity loss. For depicting the dependencies and physical risks associated with the nature, the authors use the ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure) methodology[47] and database adjusted for NACE REV 2 codes. According to the results of the study, 36 percent (EUR 510 billion) of the investments of Dutch financial institutions are highly or very highly dependent on one or more ecosystem services. The highest dependence is on the ecosystems that provide groundwater and surface water. The study also concludes that for EUR 510 billion of the total EUR 1,400 billion of investments analyzed the loss of ecosystem services would lead to substantial disruption of business processes and financial losses. As for illustrating the impacts and the transition risks associated with nature van Toor et al. (2020) uses the biodiversity footprint and expresses the results in MSA² metric[x] through shares of loans and securities shared by Dutch financial institutions (banks, pension funds and issuers) and financing activities in biodiversity hotspots.[xi] For the biodiversity footprint estimation the study uses the GLOBIO model developed by the PBL Netherlands Environmental Assessment Agency. The authors calculated worldwide biodiversity footprint of over 8,000 companies in which Dutch financial institutions invest and found out that their biodiversity footprint is comparable to the loss of 58,000 km² of pristine nature, equivalent to more than 1.7 times the land surface of the Netherlands.[xii]

The first assessment of financial sector exposure to the nature-related risks in biodiversity hotspot country was performed by the World Bank (WB).[48] For illustrating the dependencies and physical risks associated with them Calice et al. (2021) replicate some of the methodologies used by the DNB for Brazil. The ENCORE database was used for the study, linking the ecosystem services to Brazil's economic sectors and from there determining bank credit exposures to those sectors. The authors also developed scenarios and utilized the World Bank ecosystem-economy model[xiii][49]. According to the results of the study, 46 percent of Brazilian banks' non-financial corporate loan portfolio is concentrated in sectors highly or very highly dependent on one or more ecosystem services. The results of the modeling also depicted that a collapse in ecosystem services could increase the

[46] Van Toor, J., G. Schellekens, M. van Oorschot, and M. Kok. "Indebted to nature: Exploring biodiversity risks for the Dutch financial sector." De Nederlandsche Bank (2020).

[47] Developed by the Natural Capital Finance Alliance (Global Canopy, UNEP FI and UNEP-WCMC), 2021

[48] Calice, Pietro, Federico Diaz Kalan, and Faruk Miguel. "Nature-Related Financial Risks in Brazil." (2021).

[49] Johnson, Justin Andrew, Giovanni Ruta, Uris Baldos et al. "The Economic Case for Nature: A global Earth-economy model to assess development policy pathways". (2021).

cumulative long-term rate of corporate non-performing loans by 9 percentage points[xiv]. In case of the impacts and the transition risks associated with them, the authors estimate that Brazilian banks outstanding loan exposure of BRL 254 billion, or 15 percent of their corporate portfolio is to firms currently operating in Protected Areas (PAs). This exposure could increase to BRL 437 billion (or to 25 percent of the corporate credit portfolio) as conservation efforts will be increased, and to BRL 664 billion (38 percent of the corporate credit portfolio), as all priority areas become protected. In case if companies and financial institutions will fail to adapt to new Brazilian regulations and policies promoting biodiversity, consumers' preferences will likely move towards more sustainable options, and industries face legal and reputational consequences alongside with further worsening financial losses.

Following the work of van Toor et al. (2020), the Banque de France (Central Bank of France) published an assessment of the dependencies and impacts of French financial system on ecosystem services and biodiversity. In order to approximate physical risks, Svartzman et al. (2021) also used the ENCORE methodology. According to the results of the study, 42 percent of the value of securities held by French financial institutions are highly or very highly dependent on at least one ecosystem service. The highest dependence is found to be on the ecosystems that provide groundwater and surface water and on certain maintenance and regulation services (erosion control, flood protection and climate regulation). For the assessment of the transition risks, authors use the Biodiversity Impact Analytics – Global Biodiversity Score (BIA-GBS)[xv] methodology, which builds on the GLOBIO model used by the DNB. The authors find that the accumulated (or static) terrestrial biodiversity footprint of the securities held by French financial institutions is comparable to the loss of at least 130,000km² of 'pristine' nature, this corresponds to the complete artificialization of 24 percent of the area of metropolitan France[xvi]. On the other hand, the annual additional (or dynamic) impact on terrestrial biodiversity was found to be an equivalent to the loss of 4,800km² of 'intact' nature, which corresponds to 48 times the area of Paris. In addition, the authors find that most industries' biodiversity footprint is caused by indirect activities (e.g., pollution generated by a supplier).

According to the study performed by the Bank Negara Malaysia-World Bank joint collaboration, in a worst-case scenario of partial ecosystem collapse, Malaysia could experience a 6 percent GDP annual loss by 2030 compared to a baseline scenario. [50] The study used the ENCORE database to explore potential physical risks faced by the banking sector through its sectoral lending portfolio. According to the study, 54 percent of commercial banks' lending portfolio to legal entities is exposed to the sectors that depend to a high extent on ecosystem services. This high dependency exposes Malaysian banks to physical risk from ecosystem degradation, particularly related to deterioration in surface water (29 percent), climate regulation such as carbon storage (26 percent), and flood and storm protection (16 percent). The study also extended the use of ENCORE framework to estimate transition risks arising from business loans to sectors that drive impacts on nature. The results show that 87 percent of commercial banks' lending portfolio to legal entities is also exposed to sectors that strongly impact ecosystem services, particularly related to greenhouse gas (GHG) emissions (61

[50] BNM, Bank Negara Malaysia. "An Exploration of Nature-Related Financial Risks in Malaysia." (2022).

percent), water use (55 percent), and terrestrial ecosystem use (43 percent), among others. Thus, potentially facing a higher level of transition risk from changes in regulations and policies.

The Banco de Mexico, central bank of Mexico, also preformed dependencies and impacts analysis of Mexico's financial system to ecosystem services and biodiversity. [51] Following the approach first used by van Toor et al. (2020), Calice et al. (2021), and Svartzman et al. (2021), the authors used the ENCORE database to assess the exposure of the financial sector to physical and transition risks. The assessment also integrated the analysis of the temporal changes in the Natural Capital Index (NCI). Following the approach taken by Calice et al. (2021), the authors examined the intersection between the geographic distribution of business loans and protected areas. As in case with previous studies, the results indicate that a significant portion of banks' credit portfolio is highly or very highly dependent on nature and its ecosystem services. An important share of the credit portfolio has high or very high impact on ecosystem services and it is therefore subject to transition risks.

The public debate on the role of monetary policy in addressing the climate change and nature loss crises is relatively recent, and more research is required to better understand the transmission mechanisms of BRFR and broader, nature-related financial risks to inflation control and price stability, as well as to quantify the magnitude of potential impacts. However, there is growing evidence of the materiality of biodiversity-related risks and more and more central banks in emerging economies also have started the assessment of the BRFR and took initial actions. [xvii]

Despite the increasing number of studies quantitatively assessing the biodiversity-related risks, numerous challenges related-to its valuation exist. Currently, no single metric is available to capture all dependencies and impacts associated with nature loss, since biodiversity has multiple facets – species, ecosystems, ecosystem services, and genes. This is a significant challenge and represents the inability to bring together all elements of biodiversity in commensurable and comparable manner into a single metric. Also, impacts of biodiversity loss depend greatly on geographic location and ecosystem types, so an impact (e.g., in form of a loss of 1 ha of an ecosystem or 'intact' area) in one part of the world will not be equivalent to a similar impact in another.[52] Furthermore, ecological processes inherently are characterized by deep uncertainty and complex non-linearity. Indeed, ecosystems are subject to numerous tipping points and regime shifts[53], posing potential systemic risks through complex transmission channels. Thus, most of the valuation methodologies and techniques might underestimate the biodiversity-related risks.[54] Despite the challenges associated with the biodiversity and ecosystem services valuation, numerous relevant tools, databases, policies and collaborative initiatives are under development.

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[51] Serafin Martinez-Jaramillo, Franz, M., Luis O.L. Escobar-Farfán & Ricardo Montañez-Enríquez. "Dependencies and impacts of the Mexican banking sector on ecosystem services". (2023).

[52] Lammerant, J., A. Grigg, J. Dimitrijevic, K. Leach, S. Brooks, A. Burns, J. Berger, J. Houdet, M. Van Oorschot, and M. Goedkoop. "Assessment of biodiversity measurement approaches for businesses and financial institutions." (2019).

[53] Folke, Carl, Steve Carpenter, Brian Walker, Marten Scheffer, Thomas Elmqvist, Lance Gunderson, and Crawford Stanley Holling. "Regime shifts, resilience, and biodiversity in ecosystem management." (2004).

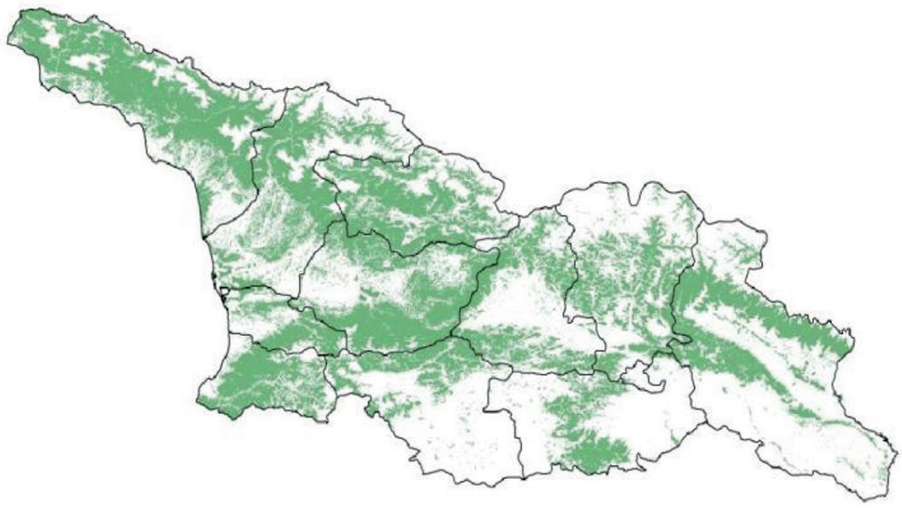
[54] Kedward, Katie, Josh Ryan-Collins, and Hugues Chenet. "Managing nature-related financial risks: a precautionary policy approach for central banks and financial supervisors". (2020).

Biodiversity Profile of Georgia

Georgia belongs to the Great Black Sea Basin region, which is one of the 35 "priority ecoregions" identified by the World Wide Fund for Nature (WWF). Additionally, Georgia is located in two of the 36 biodiversity "hotspots" recognized by Conversation International: the Caucasus and Iran-Anatolia. The Caucasus[xviii] is considered as one of the distinguished areas in the world for having high levels of diversity and endemism. More than 25 percent of the represented plant species are unique, making the Caucasus the region with the greatest percentage of endemism among temperate climate plants[xix] in the world. The Caucasus ecoregion is also home to more than 120 native vertebrate species.[55]

In Georgia, forests, which are home to the majority of all wildlife worldwide, cover around 40 percent of the country's territory (see Diagram 4), and 95–98 percent of them are of natural origin.[56,xx] About 400 different species of trees and plants are represented in the country. Among these, 43 species are unique/endemic to the Caucasus, and 61 to Georgia.[57] Moreover, Georgia's territory is comprised of a variety of unique ecosystems (such as the Colchic rainforests and wetlands), habitats, and species that are either essential to food security or have the potential to be so.[58]

Diagram 4. Georgia's forest coverage



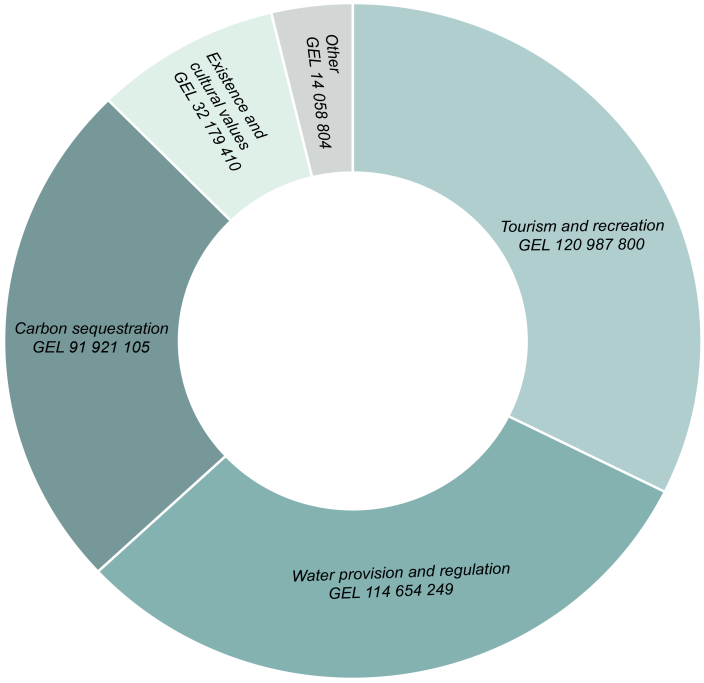
Source: MEPA, Georgia's Fifth National Report to the CBD

The protected area (PA) system in Georgia consists of 94 PAs (14 Strict Nature Reserves, 13 National Parks, 40 Natural Monuments, 24 Managed Reserves and 3 Protected Landscapes) covering about 11.42% (796,187 ha) of the country's territory. The total value of the key ecosystem services

[55] Zazanashvili, Nugzar, Sanadiradze, Giorgi, Garforth, Maia Bitsadze et al. "Ecoregional Conservation Plan for the Caucasus: 2020 Edition". Published by WWF. (2020).
[56] MEPA. "Sixth National Report to Convention on Biological Diversity". (2020)
[57] CENN. "National Forest Concept for Georgia". (2016).
[58] MEPA. "Fifth National Report to Convention on Biological Diversity". (2015)

currently provided by PAs in Georgia was estimated at approximately GEL 374 million per year with tourism and recreation (32.4 percent), water provision and regulation (30.7 percent) and carbon sequestration (24.6 percent) being the relatively more prominent services (see Diagram 5).[59]

Diagram 5. Current annual ecosystem services values associated with PAs in Georgia in GEL



Source: Adapted from Hugo van Zyl, Ekaterine Kakabadze and Irakli Goduadze (2023)

All of these make biodiversity and related ecosystem services crucial for Georgia and its economy.[60] In the case of forest ecosystems, provisioning ecosystem services in Georgia mainly provide the population with timber and non-timber resources, as well as clean water. The 46.3 percent of population in Georgia lives in rural regions and is heavily dependent on the provision of biological resources and ecosystem services.[xxi]

Regulating ecosystem services of the forest play a preventive role in development of landslides, avalanches, and mudslides. Controlling surface runoff of precipitation reduces the risk of flash floods and landslides, as well as sequestering carbon from the atmosphere and regulating climate. The abovementioned regulating ecosystem services of the forest are essential for the development of hydropower[xxii] and agriculture[xxiii] sectors.

Supporting ecosystem services create habitats and natural systems for species. About 65 percent of Caucasian species depend on forests for their existence.[61] Recreation and ecotourism are examples of cultural ecosystem services. The forest plays a significant role in the expansion of Georgia's tourist potential and associated revenue. In anticipation of a future rise in tourists, the local population is

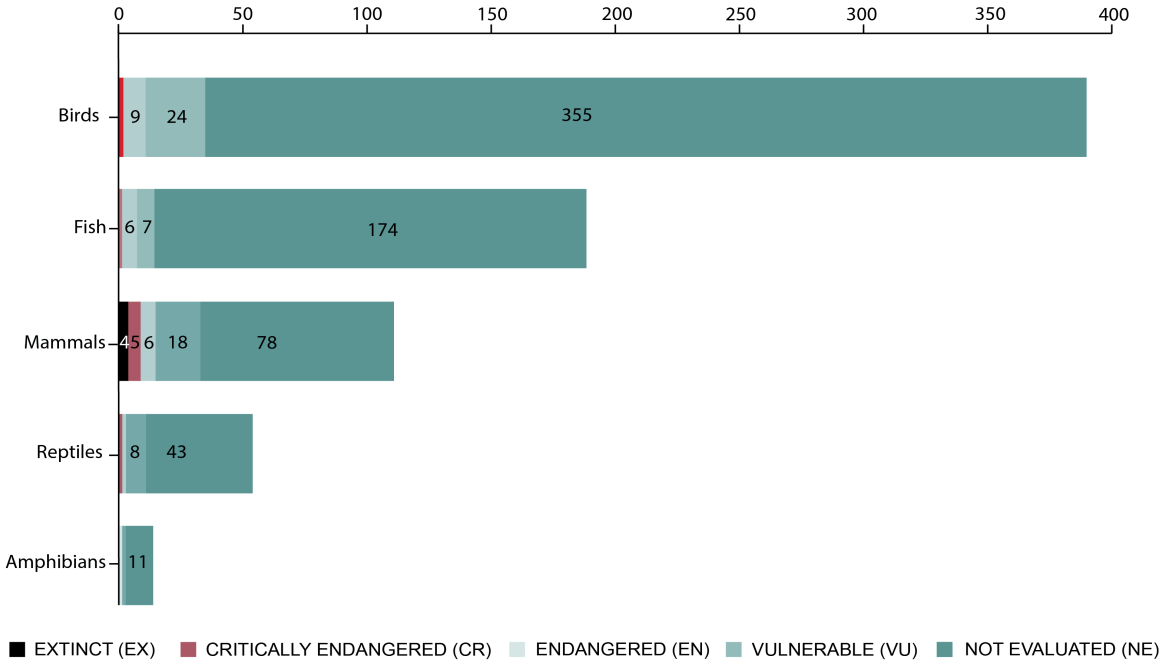
[59] Van Zyl, H.W., Kakabadze, E. and Goduadze, I. „Ecosystem Services Assessment and Cost-benefit Analysis of Investment in Georgian Protected Areas". (2023)
[60] TEEB, Recommendations of "Mainstreaming the Economics of Nature". (2010).
[61] Zazanashvili, Nugzar, Sanadiradze, Giorgi, Garforth, Maia Bitsadze et al. "Ecoregional Conservation Plan for the Caucasus: 2020 Edition". Published by WWF. (2020).

creating a network of family motels. The tourism-related activities are thought to contribute at least USD 1 million annually to the national economy.[62] The protected areas encourage the development of ecotourism and the expansion of tourism's positive economic and social effects, which is one of the sub-sectors with the quickest growth in Georgia is ecotourism.[63] [xxiv]

Agriculture, mineral and drinking water supplies, hydropower, and tourism are just a few of the industries that profit from the provisioning, regulating, supporting and cultural ecosystem services. However, the functioning of the ecosystem services depends on the levels of biodiversity and other natural assets. Thus, loss of biodiversity may negatively affect provision of ecosystem services, which in turn, will be transmitted/will have adverse effect on/ to the economy as well.

Since data on species, habitats, and ecosystems in Georgia are still limited and not systematically collected at this point, it is hard to accurately assess the state of the country's biodiversity. However, according to the studies performed as part of several international projects[64,65], many species of animals and plants that are common in Georgia are endangered on a global scale. According to the 2014 Red List of Georgia, 139 species of fauna and 56 species of flora were included in the list[xxv] (see Diagram 6). Of these, 43 animal and 20 plant species are Endangered (EN) or Critically Endangered (CR). The 44 species of vertebrates common in Georgia are threatened on a global scale and are included in the IUCN Red List as Vulnerable (VU) or more threatened species.[xxvi]

Diagram 6. The status of the fauna species in Georgia

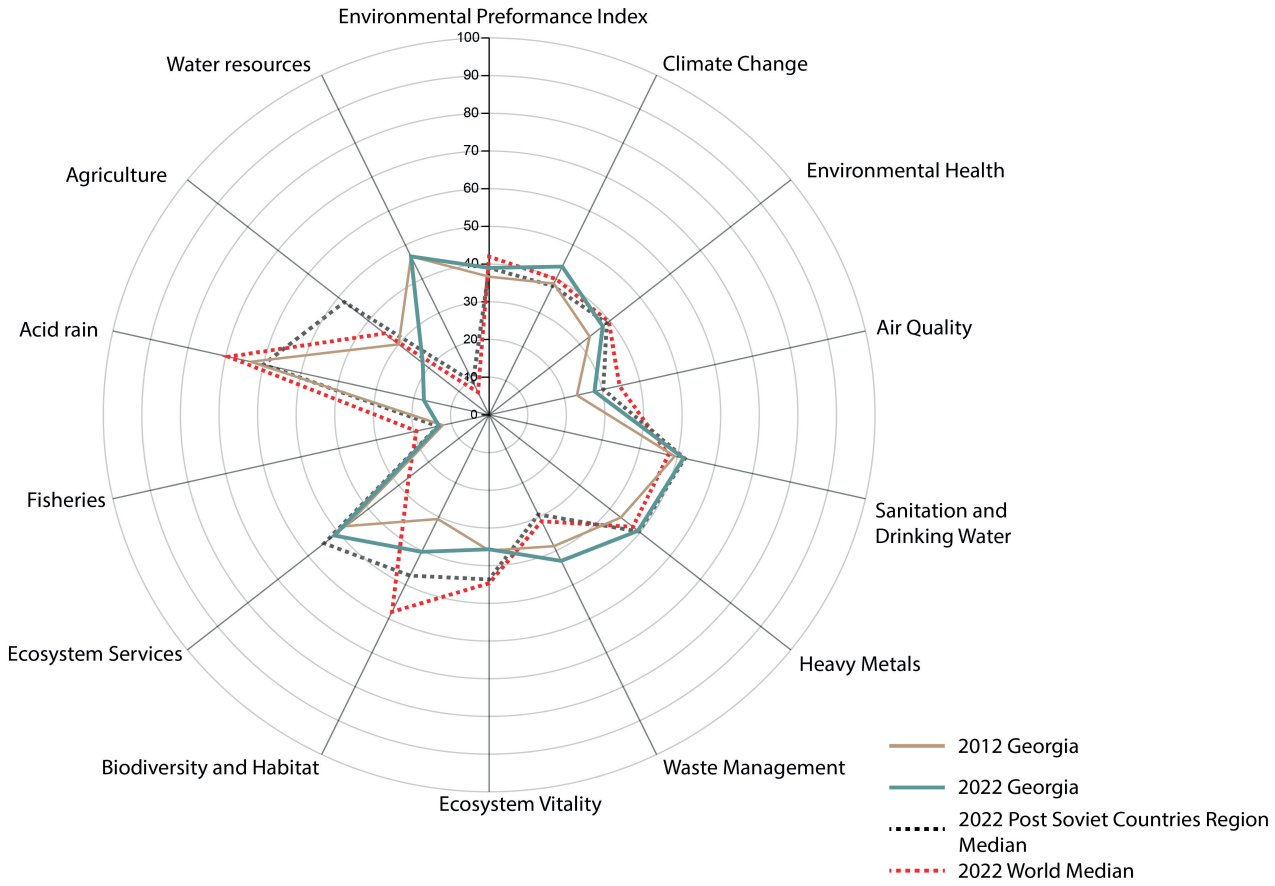


Source: MEPA, Fifth National Report to CBD (2015)

[62] Flores Marlon, Malkhaz Adeishvili. "Economic Valuation of the Contribution of Ecosystems in Protected Areas to Economic Growth and Human Well-Being in Georgia". (2012).
[63] Christian Baumgartner. „Ecotourism Strategy for Georgia 2020-2030". (2020).
[64] UNDP-GEF. "Enhancing Financial Sustainability of the Protected Areas System in Georgia." (2022).
[65] WWF Caucasus. "Development of Protected Area Network in Georgia". (2022).

As for the broader environmental conditions, according to the results from the Yale University Environmental Performance Index for Georgia for the years 2012 (brown) and 2022 (teal) (see Diagram 7), environmental performance in Georgia showed improvements in areas like environmental health, air quality, heavy metals, climate change, and ecosystem services and biodiversity indicators. In contrast, agriculture and, more notably, acidification indicators show a deterioration over the past decade. However, in most areas, Georgia's performance is comparable to and in some cases outperform, the region median and world median performance.

Diagram 7. Environmental Performance Index



Sources: Based on the Yale Environmental Performance Index (2022)

Assessment of Biodiversity-related Financial Risks in Georgia

The consequences of biodiversity loss can be catastrophic, but quantifying them is a complex task. First, data on the interaction between ecosystem services and the economy is unavailable, partly due to the fact that knowledge of ecosystem services on which the economy depends is limited. Second, it is difficult to quantify the impact of biodiversity loss on the supply of ecosystem services. Ecosystems are complex and dynamic systems with tipping points, which can bring sudden, non-linear changes that are hard to predict, and even result in the loss of an ecosystem's ability to

function.[66] In addition, the loss of one ecosystem service can, through domino effects and feedback loops, have negative consequences for other ecosystem services.

Despite the data challenges, this section tries to assess biodiversity-related risks to Georgian financial sector, both on dependencies and impacts sides.

Dependencies - Assessment of biodiversity-related physical risks

For the approximation of biodiversity-related physical risks, the research methodology adapts and expands upon the on van Toor et al.'s (2020) use of the ENCORE framework. The main assumption of the methodology is that the level of dependency of company on ecosystem services can serve to approximate the exposure of the financial system to biodiversity-related physical risks[xxvii].

ENCORE represent a database that utilizes qualitative methods to map sectors and sub-industries with their corresponding environmental dependencies and impacts via assigning a materiality ratings.[67] The ENCORE framework assesses the interdependence of 86 types of production processes with 21 ecosystem services (See Appendix 2), which are connected to eight types of natural assets.[68] The 21 ecosystem services are classified according to the Common International Classification of Ecosystem Services (CICES), which does not include cultural ecosystem services. Therefore, cultural ecosystem services are not assessed.

To measure the level of direct dependency of each production process on ecosystem services, ENCORE assigns dependency (or materiality) scores ranging from Very Low to Very High. The construction of the levels of dependency of each production process in ENCORE is the product of two factors: the degree of disruption to production processes if the ecosystem service were to disappear, and the expected ensuing financial losses.

For impacts, the rating assesses the severity of the environmental damage, its occurrence throughout the business cycle and production locations, and the feasibility of redesigning production activities to mitigate the negative impact both operationally and financially. The ENCORE scores suggest possible dependencies, rather than actual ones. Therefore, they should only be used for preliminary screening, and more detailed assessments that take into account the company's specific circumstances and location should follow to evaluate biodiversity-related physical and transition risks.

In the ENCORE framework, the levels of dependency and impacts are not regionalized. This means that, for each ecosystem service, a production process occurring in one region is considered to have the same level of dependency as the same production process in another region. Therefore, such a global average, applied by ENCORE, could over- or underestimate the dependency and impacts of specifics sectors.

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[66] Bosch, R. Ripoll. "Central banking and supervision in the biosphere: An agenda for action on biodiversity loss, financial risk and system stability: Final Report of the NGFS-INSPIRE Study Group on Biodiversity and Financial Stability". (2022).

[67] ENCORE tool, https://encore.naturalcapital.finance/

[68] ENCORE, Natural Capital Finance Alliance 2021, https://encore.naturalcapital.finance/en

Furthermore, ENCORE methodology focuses on direct nature-related impacts and dependencies for the various sectors of the economy. Thus, ENCORE can give a comprehensive view on the key first-order biodiversity-related impacts and dependencies at the level of sectors of the economy. Estimates provided in the following sections should however be considered as conservative, as the ENCORE tool only includes direct reliance of sectors on ecosystem services, whereas indirect dependencies that could stem from downstream supply chains are not captured.

The main advantage of applying ENCORE framework is that it can serve as a proxy for the measurement of multifaceted nature of BRFR. While climate change focuses primarily on the effects of anthropogenic emissions on the global temperatures, the loss of BES entails various interrelated risks such as soil degradation, depletion of water bodies, and loss of pollinators. These risks result from multiple anthropogenic drivers, such as intensive agriculture, deforestation, and pollution. By distinguishing between specific ecosystem dependencies and impact drivers, ENCORE framework also provides a completely new level of data granularity that is not present in top-down macroeconomic modeling approaches. [69]

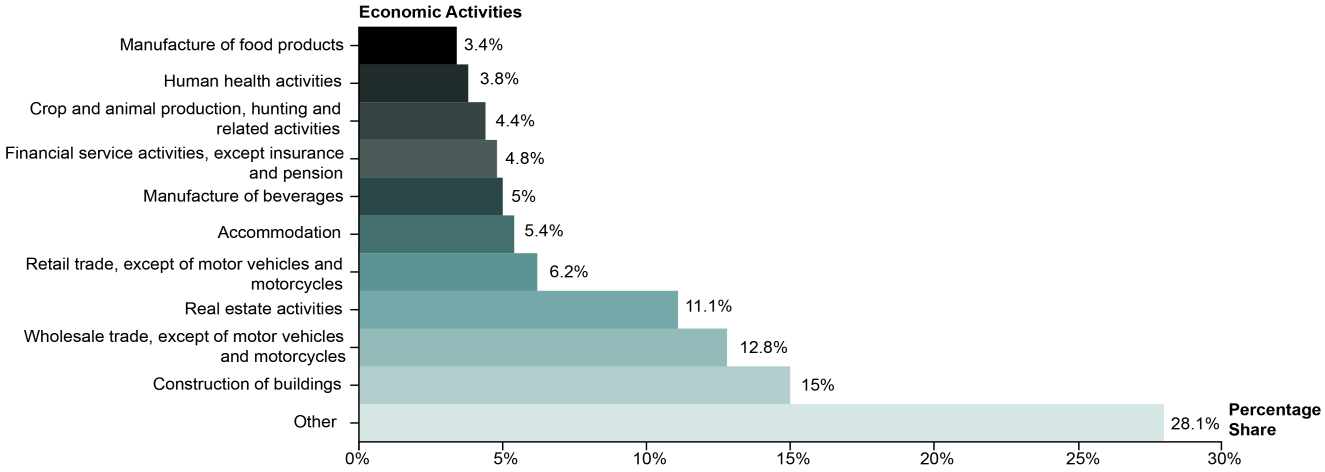
Additionally, BES related threats are the subject to a high degree of uncertainty. This is partially due to the so-called tipping points, where small changes in external factors can result in significant and perhaps irreversible shifts in the ecosystem, as opposed to risks that are emerging in a more linear and predictable manner. As a result, quantitative models may struggle to account for all tail risks associated with these environmental threats.[66,70] Instead, it has been argued that exploratory analyses, encompassing qualitative as well as quantitative approaches, may also have to focus upon key risk transmission channels in order to proxy for such uncertainty and complexity.[71,72]

Thus, while ENCORE may not offer a complete quantitative evaluation of the BRFR in quantitative terms, it does present evidence of how financial materiality related to BES loss could manifest in a portfolio. In particular, it can demonstrate which economic activities and sectors are prone to risk and which ecosystem services and drivers are linked to financial exposures.

Commercial banks play a major role in the financial sector in Georgia as they hold around 95[73] percent of total financial sector assets. Therefore, this paper relies on the analysis of the commercial banks' lending portfolio to legal entities. The portfolio is quite diversified with the construction of building, wholesale trade and real estate activities representing 38.9 percent of lending portfolio to legal entities (see Diagram 8).

[69] Kedward, Katie, Josh Ryan-Collins, and Adrienne Buller. "Quantitative easing and nature loss: Exploring nature-related financial risks and impacts in the european central bank's corporate bond portfolio." (2021).
[70] Bolton, Patrick, Morgan Despres et al. "The green swan." (2020).
[71] Kedward, Katie, Josh Ryan-Collins, and Hugues Chenet. "Managing nature-related financial risks: a precautionary policy approach for central banks and financial supervisors". (2020).
[72] Svartzman, Romain, Etienne Espagne, Gauthey Julien et al. "A'Silent Spring'for the Financial System? Exploring Biodiversity-Related Financial Risks in France." (2021).
[73] National Bank of Georgia. "Sustainable Finance Report" (2022).

Diagram 8. Business lending of Georgian banks by economic sectors, as of December 2022



Source: Author's own elaboration of NBG data (2022)

For the paper, the exposure of the financial sector to the economic sectors were determined on the basis of commercial banks' lending data to legal entities obtained from the NBG. The economic sectors are classified according to the two-digit NACE REV 2[74], which were matched with ecosystem dependency risk materiality ratings extracted from the ENCORE database.

The ENCORE framework, however, links its business processes to GICS[75]. In order to link ENCORE to financial data, GICS business activities were manually re-classified to match the two-digit NACE REV 2 nomenclature. The analysis excluded economically irrelevant activities for the Georgian economy, (for example, space transport development or cruise line provision) by manually filtering them out. For filtering the economic activities, four-digit NACE REV 2 code company data from the Service for Accounting, Reporting, and Auditing Supervision (SARAS) was used. And those activities which were not present in the SARAS database were excluded from the analysis.

To assess the dependencies of Georgian commercial banks on ecosystem services and their impact on natural capital, two assumptions were made during the analysis. In the initial stage, due to the lack of more detailed loan data, it was assumed that all business processes within the sector are proportionally represented. As a result, the loan volume for each sector was divided proportionally among its various production processes. In the second stage, it was assumed that each business process proportionally depends on each ecosystem service assigned via the ENCORE assessment tool. Therefore, the loan volume for each production process was divided proportionally among ecosystem services.

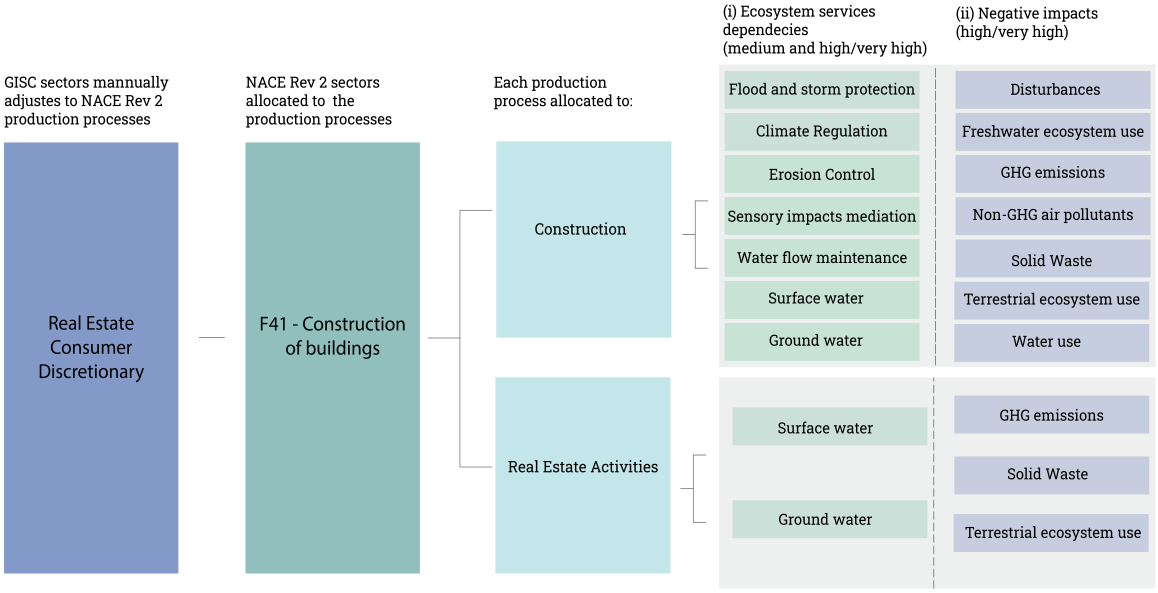
To account for the criticality of the dependency on biodiversity and ecosystem services only materiality ratings with 'moderate', 'high' and 'very high' were analyzed. Due to the fact that the ENCORE assessment framework offers limited variation in materiality ratings within the impacts database and to account for the severity of the impacts on biodiversity and ecosystem services,

[74] NACE stands for 'Nomenclature of Economic Activities' and is the European statistical classification of economic activities – https://www.nace.org/standards/nace-standards/about-nace-standards

[75] GICS stands for 'Global Industry Classification Standard' and represent a methodology for industry analysis framework for investment research, portfolio management and asset allocation - https://www.msci.com/our-solutions/indexes/gics

analysis was conducted on the materiality ratings categorized as 'high' and 'very high'. Diagram 9 provides a simplified illustration of how the GEL exposure to a specific two-digit NACE sector is represented in the ENCORE framework by identifying ecosystem dependencies and impacts. The findings represent an estimation in GEL of the potential financial exposure to moderate, high and very high dependencies upon ecosystem services and negative impacts on biodiversity within the Georgian commercial bank's business loan portfolio.

Diagram 9. Methodology for estimating financial exposure to dependencies and impacts using the ENCORE framework



Source: Authors' elaboration

According to the final outputs, approximately 46 percent of the lending portfolio (totaling to GEL 9.39 billion) of Georgian commercial banks is to economic activities (Diagram 11), which are highly or very highly dependent on one or several ecosystem services. The largest dependency of the portfolio is found for the surface water (8.12 percent), ground water (7.9 percent), flood and storm protection (6.54 percent), climate regulation (5.45 percent) and mass stabilization and erosion control (5.73 percent) ecosystem services.

Such a high dependency upon water resources might be explained by the fact that many production processes are dependent upon water-related ecosystem services in the ENCORE database. As per ENCORE's assigned materialities, 'medium', 'high' or 'very high' dependency implies that if the ecosystem services were to be lost, it would lead to disturbances in production and result in a significant financial loss ranging from moderate to severe.

The Diagram 10 below additionally represents the levels of all dependencies (in unweighted manner) to top three economic activities of the total lending portfolio.

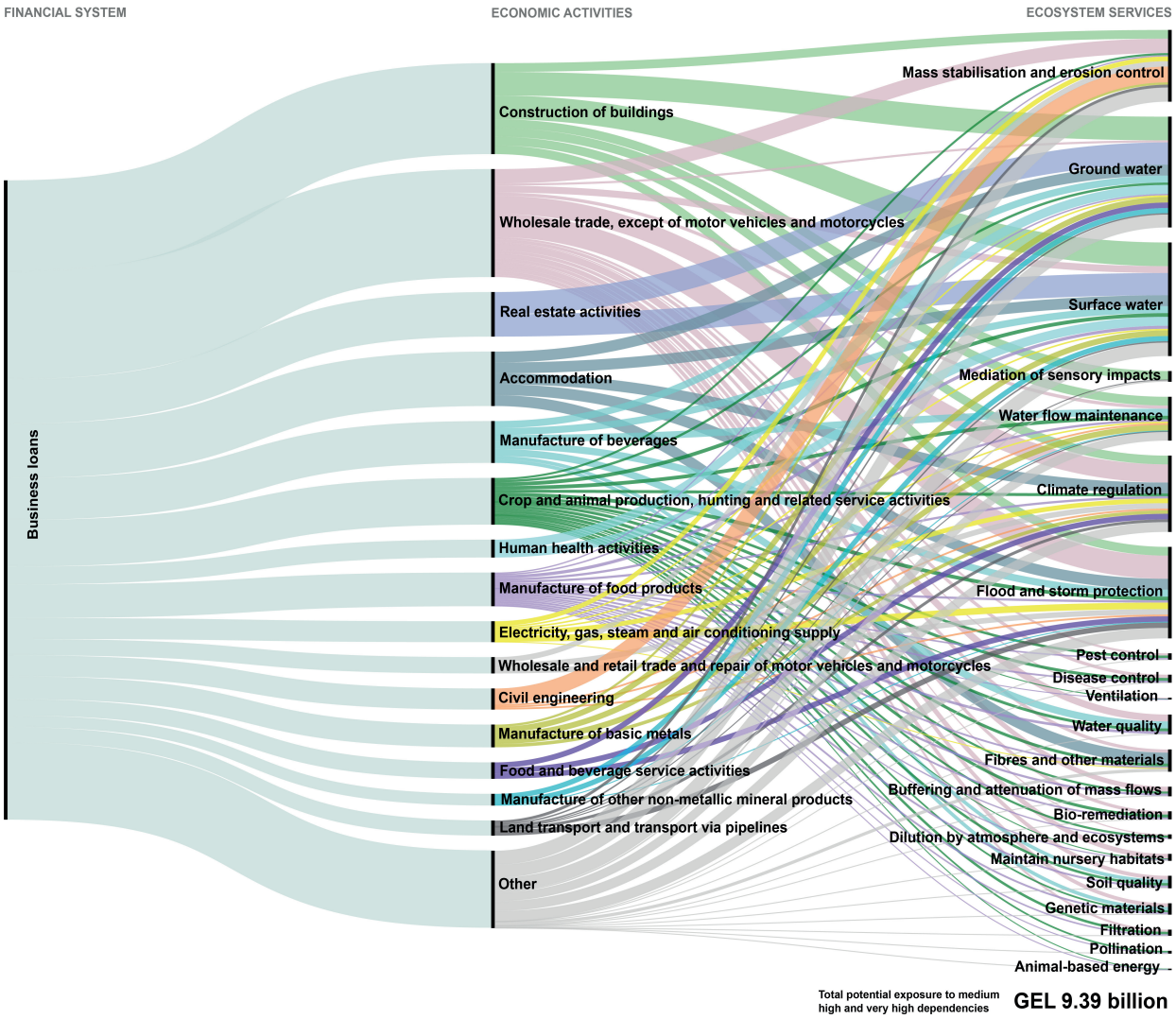
Diagram 10. The dependencies on ecosystem services for top three economic activities in the business lending portfolio of commercial banks

Source: Own calculations

As depicted on the Diagram 11 the financial sector's exposure to this high degree of water risk is linked to the size of the loans issued in real estate, accommodation and drink manufacturing economic activities - all of which are associated with high direct and/or indirect water usage.[76] This includes, first, physical risks due to the likelihood of future water scarcity making production impossible in specific locations and, second, transition and liability risks if new legislation and policies emerge for water use and pollution.

[76] Hoekstra, Arjen Y. "The water footprint of industry." (2015).

Diagram 11. The financial sector and ecosystem services dependencies



Source: Own calculations

For example, a recent submission of the draft law on Water Resources Management by the Georgian government might directly affect the operating costs of companies, which are heavily dependent on water resources. The legislative initiative sets completely new standards for water resources management and introduces a river basin management system. The issue of revising the tariff system is also be on the agenda.[77] Since the draft law introduces economic instruments of Water Resources Management, legal entities will pay the appropriate fee. The draft law has been prepared in accordance with the Georgia-EU Association Agenda and this is one of the important commitments that Georgia has made in the field of environment and is expected to be fully implemented starting from 2024 year.

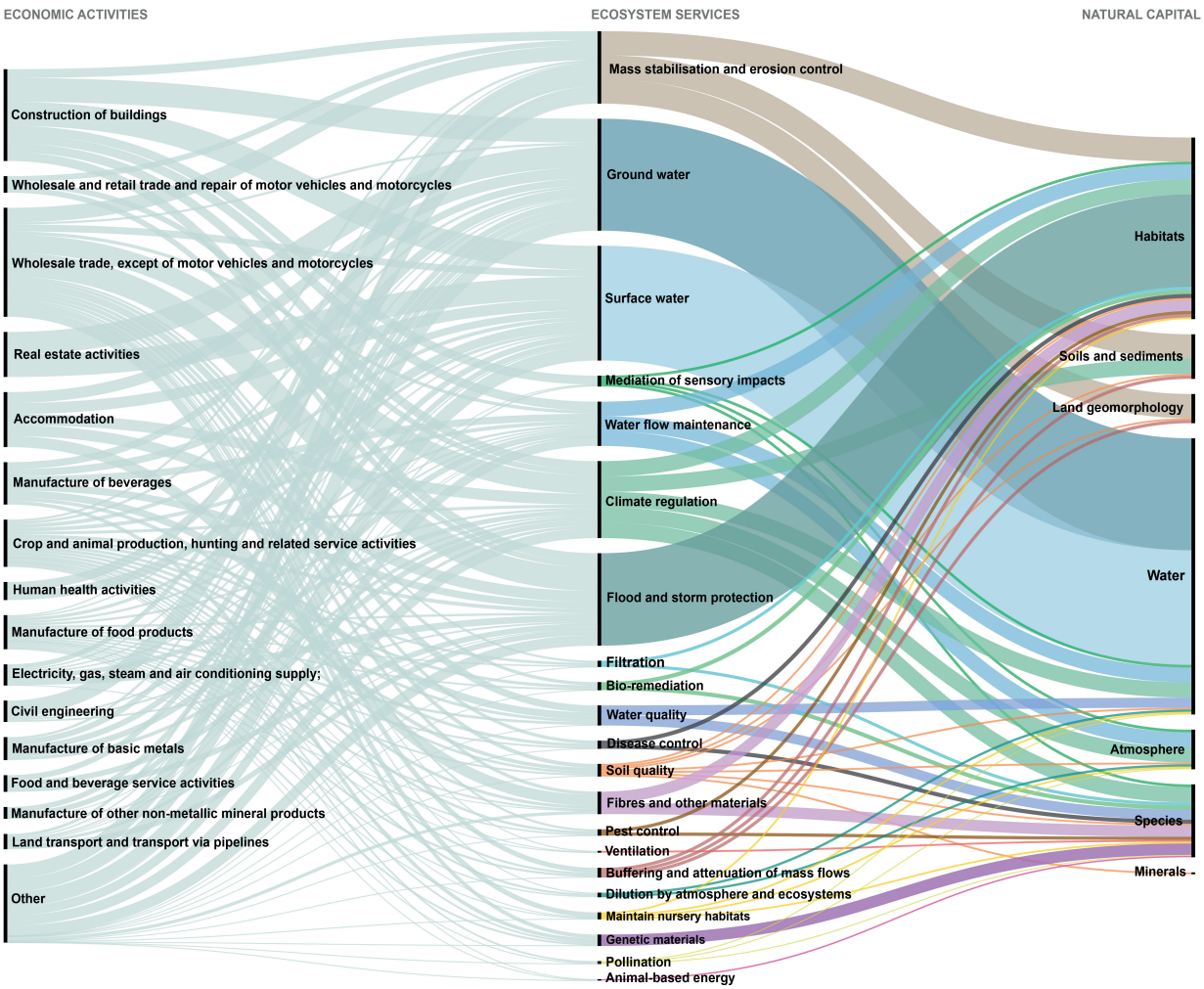
The lending portfolio of commercial banks to legal entities may also have a significant exposure to ecosystem services that safeguard the production process from natural disasters, such as flood and storm protection, climate regulation, and erosion control to stabilize the land, which can result in a

[77] Georgian Parliament. "Law to regulate the water resources management". (2022).

high or very high level of dependency. The exposure to these risks is associated with lending in sectors such as wholesale trade, civil engineering (including roads, buildings, airports, tunnels, dams, bridges), which rely on these ecosystem services to protect their critical infrastructure from damage and disruption. One of the crucial ecosystem services provided by healthy habitats and ecosystems is mass stabilisation and erosion control, where terrestrial vegetation cover protects against landslides and avalanches, and healthy coastal and wetland ecosystems provide protection against coastal and sediment erosion.[78]

Therefore, legislative changes in biodiversity and ecosystem management and/or increased investment in PA management can create new challenges for the economy and transmit it to financial sector. The improved management of BRFR would not just enhance the security and stability of individual banks and the overall financial system but it could also decrease the lending to the economic activities that have a negative impact on the environment, thus reducing the need for funding to conserve and restore biodiversity and ecosystem services.

Diagram 12. The dependency of economic activities on natural capital assets



Source: Own calculations

[78] Natural Capital Finance Alliance (Global Canopy, UNEP FI, and UNEP-WCMC). "ENCORE: Exploring Natural Capital Opportunities, Risks and Exposure." (2021)

It is crucial to note that ecosystem services cannot be separated from the natural capital assets that produce them. As Diagram 12 illustrates, habitats and species are essential in providing both flood and storm protection and climate regulation ESs (see Appendix 2 for detailed information). Therefore, a significant finding applying the ENCORE framework is that key dependencies related to water resource management and climate change are intertwined within broader biodiversity considerations.[79]

On a global scale, the estimated biodiversity gap - the difference between the current flow of public and private funds towards biodiversity preservation and the estimated yearly funding required to cease the reduction in global biodiversity from now until 2030 - amounts on average to USD 711 billion annually.[80] Although additional funding sources are required, such as mechanisms that encourage private and public investment in conservation, a substantial portion of the funding could result from financial institutions taking steps to understand and manage biodiversity-related risks associated with their investments. As the Georgian commercial banks provide lending to projects that could potentially contribute towards damaging the environment, the integration of practices that manage biodiversity-related risks across the banking industry represents a vast chance to prevent negative impacts on nature.

Impacts - Assessment of biodiversity-related transition risks

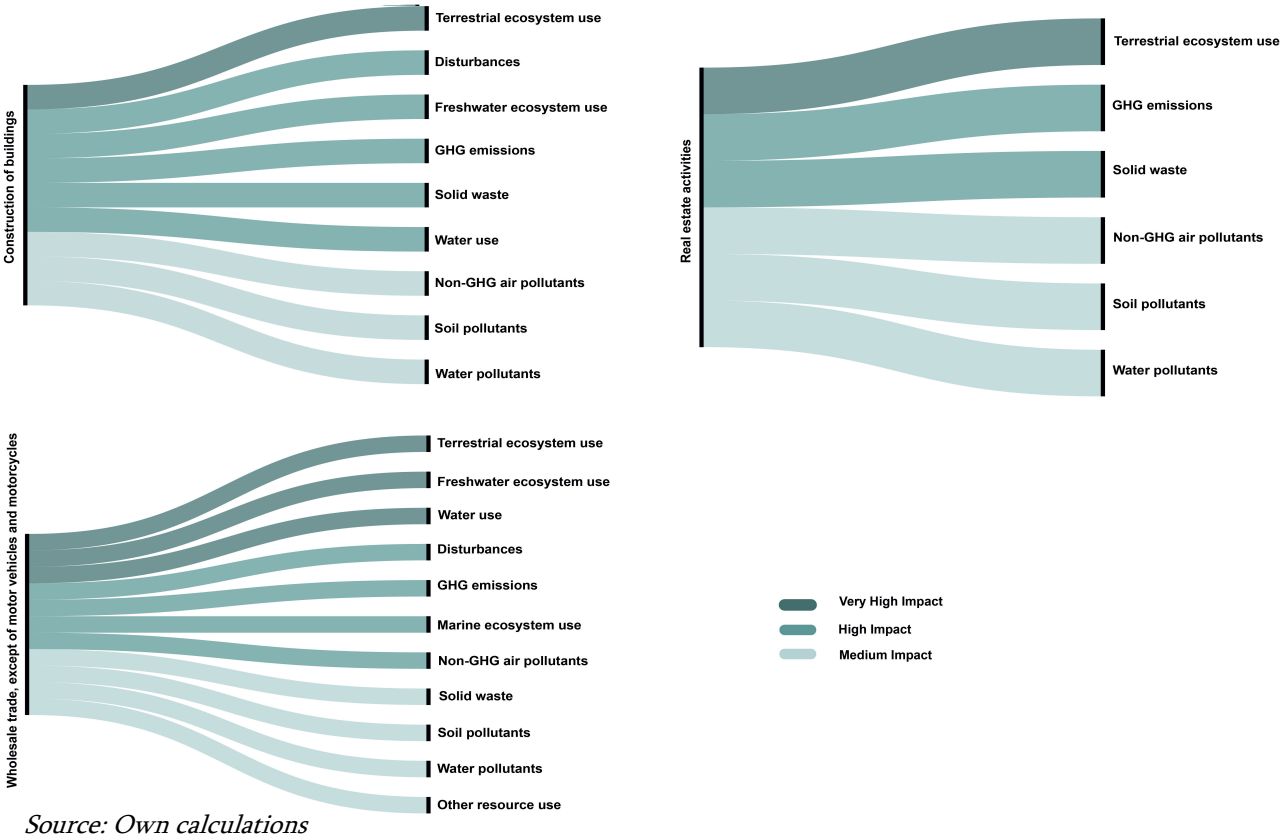
Biodiversity-related financial transition risk could emerge for Georgian commercial banks through the financing of companies that have negative impacts on BES, as these companies could face future regulatory or reputational implications.

Due to the data granularity limitations, the spatial location of companies with locations in protected areas or key biodiversity areas (KBAs) is unavailable. Therefore, for the estimation of impacts and estimation of biodiversity-related transition risks, the paper utilizes the ENCORE methodology. In a similar manner, using the ENCORE database, the impacts drivers of companies (economic activities) were determined based on the allocation of the weighting according to the materiality rating. Likewise, only linkages of economic sectors and drivers of environmental change with a high or very high impact to assess transition risk exposure are considered.

The Diagram 13 additionally represents all impacts materiality (in unweighted manner) to top three economic activities of the total lending portfolio.

[79] Kedward, Katie, Josh Ryan-Collins, and Adrienne Buller. "Quantitative easing and nature loss: Exploring nature-related financial risks and impacts in the european central bank's corporate bond portfolio." (2021).
[80] Deutz, Andrew, Geoffrey M. Heal et al. "Financing nature: Closing the global biodiversity financing gap." (2020).

Diagram 13. The impacts on BES of top three economic activities



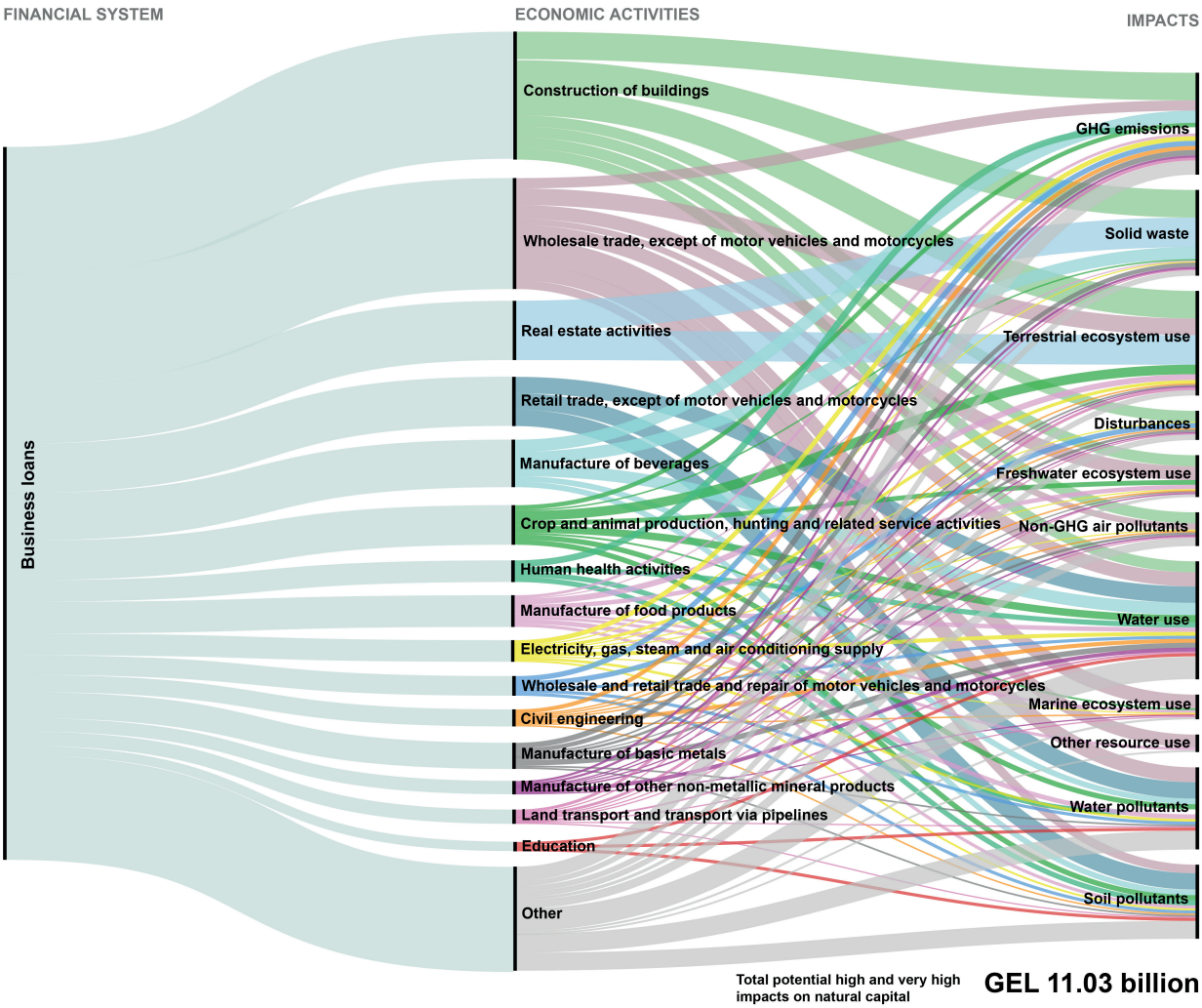
Source: Own calculations

According to the findings (Diagram 14), approximately 53.66 percent (totaling to GEL 11.03 billion) of the business loan portfolio analyzed are channeled to sectors which highly or very highly impact various natural assets and ecosystem services. Among all impact drivers, the ones individually impacted the most through commercial lending by Georgian banks are water use (8.8 percent), terrestrial ecosystem use (7.87 percent), GHG emissions (7.67 percent), solid waste (6.45 percent) and water (6.17 percent) and soil (5.57 percent) pollutants.

The business lending portfolio of Georgian banks that highly or very highly drive impacts, are mainly accounted by six sectors, which are responsible for over half of those impacts. This is both due to the size of lending exposure and the sectoral characteristics. Those sectors include construction of buildings, wholesale trade, real estate activities, and crops and animal production. Drivers of environmental impact, such as excessive water use, in turn affect the underlying natural assets, such as species, water, and habitat.

The banking sector could be particularly contributing to these drivers of environmental impacts given that Georgia represents a biodiversity hotspot (Caucasian ecoregion) and the structure of its economy largely comprises production activities that are closely tied to natural assets and ecosystems. GHG emissions, for instance, are a main driver of impact on ecosystem services by contributing to climate change, which highlights the interlinkage between climate-related and biodiversity-related risks. It further highlights the relevance of terrestrial protected areas to lower impacts, and helps to maintain key ecosystem service provision in Georgia. Enforcement of existing protected areas and the creation of new areas may pose nature transition risks to the Georgian financial sector and thus, needs to be taken into account.

Diagram 14. The impact on the biodiversity of financial sector lending



Source: Own calculations

In conclusion, exposure and contribution towards the negative impacts on BES may result in financial materiality for the Georgian commercial banks through exposure to potential transition risks, as policy and regulations on habitat loss, pollution and resource use is tightened to support a transition to a green economy.

The main uncertainties in this analysis result from the broad materiality score/rating on a sector basis used by ENCORE and the final risk calculation for each economic activity. A well-functioning tool to assess BES risk is required for better analysis, and it should include several essential components. A clear metric is needed that includes all key characteristics of BES and allows the comparison among different economic activities, sectors or even countries. The tool must consider all the key pressures of BES and allow the assessment for dependency and impact. Moreover, the tool should also consider essential variables that distinguish economic activities like the location, the sector and mitigation policies. For a better assessment of BES dependencies and impacts, future analysis should focus on obtaining detailed data, preferably directly from financial institutions. Future research should also utilize data on BES dependency and impact materiality ratings that consider geographical locations and distinguishes between economic activities.

Conclusion

This paper represent the first assessment of biodiversity-related financial risks for the Georgian banking sector, examining their lending exposure to economic sectors which depend on ecosystem services. Based on the loans to legal entities, Georgian commercial banks are exposed to a broad range of biodiversity-related physical and transition risks. The BRFR are assessed using an approach based on ENCORE methodology, which maps financial dependencies and impacts on BES.

Of the business loans portfolio analyzed, 46 percent (GEL 9.39 billion) is exposed to economic activities that highly and very highly depend on ESs. Such high dependency exposes Georgian commercial banks to physical risks stemming from ecosystem deterioration, particularly related to deterioration in surface water (8.12 percent), ground water (7.9 percent), flood and storm protection (6.54 percent), climate regulation (5.45 percent) and mass stabilization and erosion control (5.73 percent) ESs.

Of the business loans portfolio analyzed, 54 percent (GEL 11.03 billion) is also exposed to sectors that strongly and very strongly impact ecosystem services (thus potentially facing a higher level of transition risk from changes in regulations and policies), particularly related water use (8.8 percent), terrestrial ecosystem use (7.87 percent), GHG emissions (7.67 percent), solid waste (6.45 percent) and water (6.17 percent) and soil (5.57 percent) pollutants. As previously stated, this research paper faces certain challenges such as data availability and broad materiality scores/ratings. Therefore, the results obtained should be seen as potential risks rather than definitive conclusions. In order to obtain more accurate and concrete results, further analysis and more detailed data are required.

Findings of this paper could inform policymakers and supervisors and facilitate further discussions for better understanding of the BRFR on the real economy and financial sector. Further actions related to BRFR could be developed in cohesive and integrated manner within existing climate change strategies. Furthermore, the BRFR assessment conducted in this paper and initial insights it provides might play essential role in developing future fully-fledged nature stress-test. Nevertheless, addressing certain limitations and knowledge gaps would require further cooperation between various stakeholders. It is increasingly important to make efforts to assess the risks that can arise from biodiversity and ecosystem services loss and the potentially profound socioeconomic changes linked to the need to protect nature. Extreme nature-related events triggered by biodiversity loss, or 'green swan' events (e.g., future pandemics), have systemic consequences and can therefore not be measured precisely or be otherwise addressed by financial institutions, central banks or supervisors alone.

The central banks and supervisors can assist in building and managing the necessary financial architecture for scaling up sustainable finance for halting and restoring biodiversity where this is compatible with their mandates. This might include considerations on how central banks' monetary policy operations and non-monetary policy portfolio management should be conducted in the context of biodiversity loss and climate change, and how prudential regulation could be mobilized in such a way that it contributes to shifting financial flows towards sustainable outcomes, thereby strengthening the resilience of the financial system in the face of environmental risks.

Appendix

A1. Glossary

1.1 Classification of biodiversity

- **Biodiversity or biological diversity** - is defined by the United Nations Convention on Biological Diversity (CBD) as diversity of species (i.e., species diversity), variation of genes (i.e., genetic diversity) and diversity of ecosystems (i.e., ecological diversity).[81] The definition by UN Environment states that diversity includes abundance, distribution and behavior of the species, and interaction with socio-ecological systems.[82]
- **Species -** classification comprising related organisms that share common characteristics and are capable of interbreeding.[83]
- **Population** - a population consists of all the organisms of a given species that live in a particular area.
- **Community** - an interacting group of various species in a shared/ common location.
- **Habitat** – The term habitat summarizes the array of resources, physical and biotic factors that are present in an area, such as to support the survival and reproduction of a particular species. A species habitat can be seen as the physical manifestation of its ecological niche.
- **Ecosystem** - complex and dynamic systems of plants, animals and microorganisms, together with the non-living environment, interacting as a functional unit.
- **Biome -** encompass multiple ecosystems and form distinct biological communities. Nine terrestrial biomes are often identified, including tropical rainforest, desert, tundra and temperate grassland.[84]
- **Biosphere** – the part of the Earth's system, comprising all ecosystems and living organisms – the living layer of the planet. Biodiversity describes the diversity of life within the biosphere. "The biosphere refers to the sum of all the ecosystems of the world. It is both the collection of organisms living on the Earth and the space that they occupy on part of the Earth's crust (the lithosphere), in the oceans (the hydrosphere), and in the atmosphere. The biosphere is all the planet's ecosystems."[85] In this report, the terms "nature" and "biosphere" are used interchangeably.

[81] CBD. Article 2. Use of Terms. (2016).
[82] UN Environment. UNEP and Biodiversity. (2019).
[83] https://www.britannica.com/science/species-taxon
[84] Mucina, Ladislav. "Biome: evolution of a crucial ecological and biogeographical concept." New Phytologist 222, no. 1 (2019): 97-114.
[85] Diaz, Sandra Myrna, Josef Settele, Eduardo Brondízio, Hien Ngo, Maximilien Guèze, John Agard, Almut Arneth et al. "The global assessment report on biodiversity and ecosystem services: Summary for policy makers." (2019).

1.2 Terms that often get used interchangeably with biodiversity but are not the same thing

- **Nature** – refers to the world's natural features – living and non-living – that are not created by humans: plants, animals, mountains, rivers, oceans etc. Nature comprises communities of living (animals, plants, fungi) and non-living (water, climate and atmosphere) things. Together these provide the 'services' which are fundamental to human survival, such as clean water and productive soil to grow food. Nature also provides resilience to emerging threats caused by climate change. [86]
- **Wildlife** – refers to undomesticated animal species, but has come to include all organisms that grow or live wild in an area without being introduced by humans.[87]
- **Biological resources** – Bioresources, or biological resources, are all the living-based matter that result directly or indirectly from photosynthesis. It refers to biomass, which designates all the biological material and biotic elements from the ecosystems such as plants, animals, micro-organisms or biowastes. Bioresources are photosynthesis carbon products that are also restorable from this natural process. [88]
- **Natural resources** – are materials or substances occurring in nature that can be exploited for economic gain. They may be renewable, and derived from living resources, such as timber, bush meat, and firewood; or finite, and derived from inanimate sources, such as oil and gas and minerals. Biodiversity secures the long-term production of these resources.[89]
- **Natural assets** - biophysical assets of the natural environment. These consist of biological assets (produced or wild), land and water areas with their ecosystems, subsoil assets and air.[90]
- **Natural capital** – refers to the stock of renewable and nonrenewable natural resources that are used by economic units, including flows of nonrenewable resources like energy and minerals as well as ecosystem services.[91] Natural capital represent the value of nature and biodiversity to financial regulators and supervisors. A parallel is drawn to financial systems where stocks of financial capital generate financial flows. Similarly, natural capital is the world's stock of natural assets such as water, land, soil and wildlife, from which flow a multitude of valuable goods and services.
- **Biomass -** refers to the plant or animal material used as fuel to produce electricity or heat. Examples are wood, energy crops and waste from forests, yards, or farms. Since biomass technically can be used as a fuel directly, some people use the terms biomass and biofuel interchangeably.
- **Ecosystem services** – the flows of benefits that people gain from natural ecosystems. Ecosystem services are usually divided into three-four categories depending on the classification. Provisioning services are tangible products of ecosystems, such as food, timber and cotton. Regulating services are the benefits of the regulating processes, such as

[86] IPBES. Glossary (2022).
[87] Usher, Michael B. "Wildlife conservation evaluation: attributes, criteria and values." (1986).
[88] Clara Censi, Tom Beneteau, Charlotte Ané, Bernard Reilhac. "Bioresources". (2020)
[89] Dilys Roe, Nathalie Seddon and Joanna Elliott. "Biodiversity loss is a development issue: a rapid review of evidence". IIED. (2019).
[90] Glossary of Environment Statistics, Studies in Methods, Series F, No. 67, United Nations, New York, 1997.
[91] United Nations SEEA. Natural capital and ecosystem services FAQ. (2020)

animal pollination, air and water treatment, and soil fertility. Cultural services are the non-material benefits of ecosystems, such as their contributions to education, recreation and tourism. Finally, nature provides supporting services, such as the nutrient cycle, soil conservation and habitat creation, which actually support the other three categories of ecosystem services.[92]

1.3 Types of species and measurement methods

- **Endemic species** - plant and animal species that are found in a particular geographical region and nowhere else in the world.
- **Pioneer species** - the first ones to colonize a bare substrate in primary succession while first to colonize a destroyed habitat in secondary succession.
- **Dominant species** - species that have high abundance relative to other species in a community, and have proportionate effects on environmental conditions, community diversity and/or ecosystem function.
- **Foundation species** - locally abundant and uniquely control associated biodiversity, whereas dominant species are locally abundant but are thought to be replaceable in ecological systems. It is important to distinguish foundation from dominant species to direct conservation efforts.
- **Keystone species** – species that has a disproportionately large effect on its natural environment relative to its abundance
- **Native species** - indigenous species of animals or plants that naturally occur in a given region or ecosystem.
- **Invasive species** – an organism that is not indigenous, or native, to a particular area.
- **Species richness** - the number of species in a community.
- **Species abundance** - the measure of the number or frequency of individuals of the same species
- **Species diversity** – the number of species present (species richness) and their abundance (species evenness) in an area or in a community (also referred as **taxonomic diversity**).
- **Phylogenetic diversity** - the presence of different evolutionary lineages
- **Functional diversity** - the variety of growth forms and resource use strategies

1.4 Direct drivers of biodiversity loss

- **Climate change** - Change in climate attributed directly or indirectly to human activity.[93] When climate conditions are destabilized, ecosystem services are disrupted and biodiversity is lost.
- **Invasive species** - Species whose introduction by humans threatens biodiversity. The species will not be native and is described as invasive if it expands into and modifies the ecosystem.[94]

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[92] TEEB, Recommendations of "Mainstreaming the Economics of Nature". (2010).
[93] United Nations Framework Convention on Climate Change. Articles 1: Definitions.
[94] IPBES. Invasive alien species.

- **Land use change** - Change in the use or management of land by humans. This may lead to a change in the quality or extent of natural habitat, which has knock-on effects for ecosystem services.
- **Overexploitation of natural resources** - Using natural resources or harvesting species from the wild at rates faster than then they can recover.
- **Pollution** - Introduction of materials into the environment that harm nature. Pollution can be of air, water and/or land.

1.5 Indirect drivers of biodiversity loss

- **Demographic** – Human population dynamics play a crucial role in shaping both the demand and supply of ecosystem services. A high population density leads to increased pressure on ecosystems, causing a high demand for these services, whereas low population density, as seen in rural areas where people are moving away, decreases the demand and results in the abandonment of farmland.
- **Social and economic factors** – Set of social-economic factors (e.g., income, education, equality, poverty etc.) also plays a crucial role in determining the demand and supply of ecosystem services. These factors also affect the ability of people to make sustainable choices.
- **Technological innovation** - The development of new technology can promote the use of greener energy sources and reduce harm to the environment, but it may also have unintended consequences such as electronic waste and the depletion of resources for the production of new tech products.
- **Institutions and governance** - Institutions and governance play a vital role in the sustainable management of ecosystems as they significantly influence values and decision-making processes, determining behavior.

1.6 Results of nature loss

- **Environmental degradation** - the deterioration in environmental quality from ambient concentrations of pollutants and other activities and processes such as improper land use and natural disasters.[95] It includes the loss of biodiversity, which is the variability among living organisms and the ecological communities of which they are part.[96]
- **Nature loss** – is a decline of natural capital, ecosystem services and biodiversity.
- **Biodiversity loss** – extinction of species worldwide, as well as the local reduction or loss of species in a certain habitat, resulting in a loss of biological diversity. The latter phenomenon can be temporary or permanent, depending on whether the environmental degradation that leads to the loss is reversible through ecological restoration/ecological resilience or effectively permanent (e.g. through land loss).

[95] Glossary of Environment Statistics, Studies in Methods, Series F, No. 67, United Nations, New York, 1997.
[96] CBD. (2006). Article 2. Use of Terms.

- **Habitat degradation** – A general term describing the set of processes by which habitat quality is reduced. Habitat degradation may occur through natural processes (e.g. drought, heat, cold) and through human activities (forestry, agriculture, urbanization).[97]
- **Habitat fragmentation** – is defined as the process during which a large expanse of habitat is transformed into a number of smaller patches of smaller total area isolated from each other by a matrix of habitats unlike the original.[98]

1.7 Types of nature-related risks

- **Climate-related financial risks** - the set of potential risks that may result from climate change and that could potentially impact the safety and soundness of individual financial institutions and have broader financial stability implications for the banking system.[99]
- **Biodiversity-related financial risks** - the set of potential risks that may result from biodiversity loss and ecosystem degradation and that could potentially impact the safety and soundness of individual financial institutions and have broader financial stability implications for the banking system
- **Nature-related financial risks** – is particularly used by the Taskforce on Nature-related Financial Disclosures (TNFD) and the Network for Greening the Financial System (NGFS). It can generally be used interchangeably with biodiversity-related financial risks; however, the term also recognizes the interlinkages between the climate change, biodiversity and other environmental disruptions.
- **Environment-related financial risks** – is defined by the NGFS as risks posed by the exposure of financial institutions to activities that may potentially cause or be affected by environmental degradation and the loss of ecosystem services.[100] Environment-related financial risks are also referred to financial risks associated with climate change, biodiversity loss, and the broader degradation of ecosystems – as well as the interconnections between them.

[97] IPBES. (2019). Habitat degradation
[98] Fahrig, Lenore. "Effects of habitat fragmentation on biodiversity." Annual review of ecology, evolution, and systematics (2003): 487-515.
[99] Bank for International Settlements. (2020). Climate-related financial risks: a survey on current initiatives.
[100] NGFS. (2020). Overview of the environmental risks analysis by financial institutions.

A2. ENCORE Definitions

Table 2. List of ecosystem services included in the ENCORE database with their description

Ecosystem Service	Ecosystem service Description
Animal-based energy	Physical labour is provided by domesticated or commercial species, including oxen, horses, donkeys, goats and elephants. These can be grouped as draught animals, pack animals and mounts.
Bio-remediation	Bio-remediation is a natural process whereby living organisms such as micro-organisms, plants, algae, and some animals degrade, reduce, and/or detoxify contaminants.
Buffering and attenuation of mass flows	Buffering and attenuation of mass flows allows the transport and storage of sediment by rivers, lakes and seas.
Climate regulation	Global climate regulation is provided by nature through the long-term storage of carbon dioxide in soils, vegetable biomass, and the oceans. At a regional level, the climate is regulated by ocean currents and winds while, at local and micro-levels, vegetation can modify temperatures, humidity, and wind speeds.
Dilution by atmosphere and ecosystems	Water, both fresh and saline, and the atmosphere can dilute the gases, fluids and solid waste produced by human activity.
Disease control	Ecosystems play important roles in regulation of diseases for human populations as well as for wild and domesticated flora and fauna.
Fibres and other materials	Fibres and other materials from plants, algae and animals are directly used or processed for a variety of purposes. This includes wood, timber, and fibres which are not further processed, as well as material for production, such as cellulose, cotton, and dyes, and plant, animal and algal material for fodder and fertiliser use.
Filtration	Filtering, sequestering, storing, and accumulating pollutants is carried out by a range of organisms including, algae, animals, microorganisms and vascular and non-vascular plants.
Flood and storm protection	Flood and storm protection is provided by the sheltering, buffering and attenuating effects of natural and planted vegetation.
Genetic materials	Genetic material is understood to be deoxyribonucleic acid (DNA) and all biota including plants, animals and algae.
Ground water	Groundwater is water stored underground in aquifers made of permeable rocks, soil and sand. The water that contributes to groundwater sources originates from rainfall, snow melts and water flow from natural freshwater resources.
Maintain nursery habitats	Nurseries are habitats that make a significantly high contribution to the reproduction of individuals from a particular species, where juveniles occur at higher densities, avoid predation more successfully, or grow faster than in other habitats.
Mass stabilisation and erosion control	Mass stabilisation and erosion control is delivered through vegetation cover protected and stabilising terrestrial, coastal and marine ecosystems, coastal wetlands and dunes. Vegetation on slopes also prevents avalanches and landslides, and mangroves, sea grass and macroalgae provide erosion protection of coasts and sediments.
Mediation of sensory impacts	Vegetation is the main (natural) barrier used to reduce noise and light pollution, limiting the impact it can have on human health and the environment.
Pest control	Pest control and invasive alien species management is provided through direct introduction and maintenance of populations of the predators of the pest or the invasive species, landscaping areas to encourage habitats for pest reduction, and the manufacture of a family of natural biocides based on natural toxins to pests.
Pollination	Pollination services are provided by three main mechanisms: animals, water and wind. The majority of plants depend to some extent on animals that act as vectors, or pollinators, to perform the transfer of pollen.

Soil quality	Soil quality is provided through weathering processes, which maintain bio-geochemical conditions of soils including fertility and soil structure, and decomposition and fixing processes, which enables nitrogen fixing, nitrification and mineralisation of dead organic material.
Surface water	Surface water is provided through freshwater resources from collected precipitation and water flow from natural sources.
Ventilation	Ventilation provided by natural or planted vegetation is vital for good indoor air quality and without it there are long term health implications for building occupants due to the build-up of volatile organic compounds (VOCs), airborne bacteria and moulds.
Water flow maintenance	The hydrological cycle, also called water cycle or hydrologic cycle, is the system that enables circulation of water through the Earth's atmosphere, land, and oceans. The hydrological cycle is responsible for recharge of groundwater sources (i.e. aquifers) and maintenance of surface water flows.
Water quality	Water quality is provided by maintaining the chemical condition of freshwaters, including rivers, streams, lakes, and ground water sources, and salt waters to ensure favorable living conditions for biota.

Source: ENCORE, Natural Capital Finance Alliance 2021

Table 3. List of natural capital assets included in the ENCORE database with their description

Asset	Description
Atmosphere	The atmosphere is the mass of air surrounding the earth. It's components (such as oxygen) and it's processes (such as temperature regulation) support a number of essential ecosystem services.
Habitats	Habitats refer to the conditions of the environment necessary for life to prosper. These conditions vary widely between species but can include such elements as water and food availability, temperature range, or absence of predators. Habitats can be defined very narrowly for one population of a particular species or more widely by type such as forests or coastal habitats that host many different species.
Land geomorphology	Land geomorphology describes the structure of the land, such as mountains and valleys. Land geomorphology supports the provision of regulatory services, like erosion control.
Minerals	Minerals are naturally occuring compounds not produced by living beings. They can be metallic or non-metallic and play an important supporting role in the provision of services like soil quality.
Ocean geomorphology	Ocean geomorphology describes the structure of the marine environment such as shelfs and slopes. Ocean geomorphology supports the provision of regulatory services, like dilution by ecosystems.
Soils and sediments	Soils and sediments are the layers of the earth's surface that support life. They comprise top-soil, sub-soil and ocean sediments and support a number of regulatory services.
Species	Species includes plants, animals, fungi, algae and genetic resources, which can be wild or domestic/commercial, for example livestock. Like habitats, species underpin a wide range of ecosystem services.
Water	Water includes surface water, ground water, ocean water, fossil water and soil water. Water is essential for a wide range of ecosystem services.

Source: ENCORE, Natural Capital Finance Alliance 2021

Table 4. List of impact drivers included in the ENCORE database with their description

Impact drivers	Description
Disturbances	Examples include decibels and duration of noise, lumens and duration of light, at site of impact.
Freshwater ecosystem use	Examples include area of wetland, ponds, lakes, streams, rivers, or peatland necessary to provide ecosystem services such as water purification, fish spawning, areas of infrastructure necessary to use rivers and lakes such as bridges, dams, and flood barriers, etc.
GHG emissions	Examples include volume of carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), Sulphur hexafluoride (SF6), Hydrofluorocarbons, (HFCs) and perfluorocarbons (PFCs), etc.
Marine ecosystem use	Examples include area of aquaculture by type, area of seabed mining by type, etc.
Non-GHG air pollutants	Examples include volume of fine particulate matter (PM2.5) and coarse particulate matter (PM10), Volatile Organic Compounds, mono-nitrogen oxides (NO and NO2, commonly referred to as NOx), Sulphur dioxide (SO_2), Carbon monoxide (CO), etc.
Soil pollutants	Examples include volume of waste matter discharged and retained in soil over a given period.
Solid waste	Examples include volume of waste by classification (i.e., nonhazardous, hazardous, and radioactive), by specific material constituents (e.g., lead, plastic), or by disposal method (e.g., landfill, incineration, recycling, specialist processing).
Terrestrial ecosystem use	Examples include area of agriculture by type, area of forest plantation by type, area of open cast mine by type, etc.
Water pollutants	Examples include volume discharged to receiving water body of nutrients (e.g., nitrates and phosphates) or other substances (e.g., heavy metals and chemicals).
Water use	Examples include volume of groundwater consumed, volume of surface water consumed, etc.
Other resource use	Examples include volume of mineral extracted, volume of wildcaught fish by species, number of wild-caught mammals by species, etc.

Source: ENCORE, Natural Capital Finance Alliance 2021

Table 5. List of drivers of environmental change included in the ENCORE database with their description

Driver of environmental change	Description
Diseases	Harmful pathogens and microbes that are originally found within the ecosystem(s) in question, but have become "out-of-balance" or "released" directly or indirectly due to human activities.
Droughts	Periods in which rainfall falls below the normal range of variation.
Earthquakes	Earthquakes manifest themselves by shaking and displacing or disrupting the ground. They may also cause associated events such as tsunamis, landslides, or even volcanic activity.

Fire	Suppression or increase in fire frequency and/or intensity outside of its natural range of variation.
Flooding	Extreme precipitation events leading to the submergence of dry land.
Landslides	Landslide events leading to geological changes.
Habitat modification	Major changes in habitat composition and location, for example deforestation.
Human modification of genetic material	Human altered or transported organisms or genes.
Human movement	Migration by people from one place to another with the intentions of settling, permanently or temporarily in a new location.
Industrial or domestic activities	Non-agricultural human activities including non-consumptive use of resources.
Industrial or domestic construction	Process of constructing a building or infrastructure for industrial or domestic purposes.
Intensive agriculture and aquaculture	Threats from farming and ranching as a result of agricultural expansion and intensification, including silviculture, mariculture and aquaculture (includes the impacts of any fencing around farmed areas).
Invasive species	Harmful plants, animals, pathogens and other microbes not originally found within the ecosystem(s) in question and directly or indirectly introduced and spread into it by human activities.
Ocean acidification	Changes to the ocean chemistry which occurs when carbon dioxide is absorbed from the atmosphere and reacts with seawater to produce acid.
Ocean current and circulation	Large scale movement of waters in the ocean basins.
Overfishing	The harvesting of aquatic wild animals or plants at a rate that is greater than their capacity for regeneration. Harvesting can occur for commercial, recreation, subsistence, research, or cultural purposes, or for control/persecution reasons; accidental mortality/bycatch are also included.
Overharvesting	The harvesting of plants, fungi, trees and other woody vegetation, and other non-timber/non-animal products at a rate that is greater than their capacity for regeneration. The harvesting can occur for commercial, recreation, subsistence, research or cultural purposes, or for control reasons.
Overhunting	The killing or trapping terrestrial wild animals or animal products at a rate that is greater than their capacity for regeneration. The killing or trapping can occur for commercial, recreation, subsistence, research or cultural purposes, or for control/persecution reasons; includes accidental mortality/bycatch.
Pests	Harmful plants or animals that are originally found within the ecosystem(s) in question, but have become “out-of-balance” or “released” directly or indirectly due to human activities.
Pollution	Threats arising from the introduction of contaminants into the natural environment.
Population changes	Changes in species populations over time and space.
Sea level rise	Increase in global mean sea level as a result of an increase in the volume of water in the world's oceans or heat dilation.
Sea surface temperature	Periods in which sea surface temperatures exceed or go below the normal range of variation.
Storms	Extreme precipitation and/or wind events.
Volcanoes	Volcanic events which may lead to changes in natural capital assets.
Water abstraction	Changing water flow patterns from their natural range of variation due to human activities.
Weather conditions	Weather conditions outside of the natural range of variation.

Source: ENCORE, Natural Capital Finance Alliance 2021

Abbreviations

- **BES** – Biodiversity and ecosystem services
- **BRFR** – Biodiversity-related financial risks
- **CBD** – Convention on Biological Diversity
- **CO2/CO2e** - Carbon Dioxide/Carbon Dioxide Equivalent
- **CRFR** – Climate-related financial risks
- **DNB** – De Nederlandsche Bank [Central Bank of Netherlands]
- **ESG** – Environmental, Social and Governance
- **ES** – Ecosystem Services
- **ENCORE** – Exploring Natural Capital Opportunities, Risks and Exposure
- **EU** – European Union
- **GDP -** Gross Domestic Product
- **GHG** - Greenhouse Gas
- **INSPIRE** - International Network for Sustainable Financial Policy Insights, Research, and Exchange
- **IPBES** – Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
- **IPCC** – Intergovernmental Panel on Climate Change
- **LPI** – Living Planet Index
- **NACE** - Statistical Classification of Activities in the European Community
- **NGFS** – The Network for Greening the Financial System
- **NRFR** – Nature-related Financial Risks
- **MEPA** - Ministry of Environment Protection and Agriculture
- **MSA** - Mean Species Abundance
- **PAs** – Protected Areas
- **SDGs** – Sustainable Development Goals
- **UNEP** – United Nations Environment Programme
- **WB** – World Bank
- **WEF** – World Economic Forum
- **WWF** – World Wide Fund for Nature

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Endnotes

[i] For the detailed explanation of the terms view the glossary part of the report.
[ii] This report uses the terms “nature” and “biodiversity and ecosystem services” to refer to the ensemble of living organisms and the functions of the biosphere.
[iii] As yields and productivity take a hit from the loss of nature’s services, volume and quality of supply may be affected, and prices will likely rise (PwC, 2020) For example, it is estimated that crops worth up to $577 billion are at risk annually from the loss of pollinators threatening the availability of crops such as cocoa, coffee and soy (IPBES, 2016).
[iv] Damaged ecosystems can no longer provide a natural buffer against floods and other extreme weather events, putting both raw materials and built assets at risk for all types of businesses (PwC, 2020).
[v]

- In France, Article 29 of the Energy-Climate Law suggests the integration of BRFRs into the reporting practices of financial actors; it was the first country to make it mandatory.
- The EU Deforestation law will require mandatory due diligence rules to allow only deforestation-free and legal products into the EU market (European Commission, 2021d).
- In April 2022, the European Commission accepted the registration of a citizens' initiative called "End The Slaughter Age", which proposes to remove all subsidies dedicated to the livestock sector in favor of ethical and ecological alternatives such as cellular agriculture or plant proteins (European Commission, 2022b)
- In June 2022, the European Commission introduced the proposal for the Restoration Law. It does not place any direct obligations on private actors but only on Member States. Nevertheless, it demands that Member States formulate National Restoration Plans, which should indicate the estimated financing needs for implementation of the restoration measures, as well as means of intended financing, public or private (European Commission, 2022b).
- The EU Farm to Fork Strategy aims to reduce pesticide usage by 50 per cent and fertiliser inputs by 20 per cent by 2030.
- The EU Soil Health Law that will be passed by 2023, setting strict rules on using soil, possibly at the level of current water and air quality directives (European Commission, 2021b).

[vi] According to IPBES (2019) financial institutions are exposed to the increasing biodiversity risks since the quantity and quality of ecosystems have decreased by 47% globally compared to anticipated baselines.
[vii] Biodiversity loss leads (in a non-linear way) to the loss of ESs, industries that are highly dependent on these ESs, directly or indirectly through their value chain, will be the most affected.
[viii] A decline in animal pollinators can reduce cacao yields. This not only has an impact on cacao farmers, but also on chocolate producers. For example, Dutch financial institutions worldwide have €510bn in exposure to companies with high or very high dependency on one or more ecosystem services (DNB. (2020). Indebted to Nature)
[ix] Nature degradation increases the intensity of natural disasters and is often the factor that transforms a natural hazard or climatic extreme into a disaster.
[x] The Mean Species Abundance (MSA) metric describes biotic integrity, ranges from 0 to 100% and can be integrated spatially.
[xi] Financial institutions will face transition risks should governments seek to protect these areas, reducing or halting impactful economic activities.
[xii] This biodiversity footprint is used in the study as an indicator for transition risk, where a large footprint can be used as an indicator of increased risk. Also, for the additional assessment of exposure to the transitional risks, the authors examined the efforts of financial institutions to reduce nitrogen emissions in the Netherlands. The study found a total of €81 billion in loans from the three largest Dutch banks to companies that emit nitrogen.
[xiii] The World Bank ecosystem-economy modeling combines a general equilibrium model with a set of ecosystem service models that cover pollination, timber provision, fisheries, and carbon sequestration, whose interactions with the economy are projected to the year 2030.

[xiv] This assessment was based on an estimate of the effects of a collapse in ecosystem services on Brazil's GDP, and a macroeconomic modeling of the historical sensitivity of Brazilian banks' asset quality to macroeconomic conditions.
[xv] Global Biodiversity Score (GBS) is developed by CDC Biodiversité (2020) and its translation to a database is developed by Carbon4Finance (BIA-GBS).
[xvi] The analysis assessed the impacts (or footprint) on terrestrial biodiversity of these financial institutions through the activities of the companies whose securities they hold. The utilized tool first converts a company's turnover by region and production sector into pressures on biodiversity (in terms of climate change or land use, for example), then into an impact expressed in a single metric, the MSA.km². An impact of 1 MSA.km² can be interpreted as having the same effect on biodiversity as transforming 1km² of pristine ecosystem into a completely artificial surface.
[xvii] Central Bank of Brazil (BCB) and Central Bank of Malaysia (BNM) have collaborated with the World Bank to explore nature-related financial risks. Central Bank of Hungary (MNB) in collaboration with OECD is developing a supervisory framework for financial risks stemming from biodiversity-related losses.
[xviii] The Caucasus ecoregion spans an area of 586,800 km2, and it comprises the territories of Armenia, Azerbaijan, and Georgia, as well as the territories of Russian Federation's (North Caucasus region), parts of northeastern Turkey, and northwestern Iran.
[xix] The Caucasus is home to 2,791 plant species and 21 genera that are unique to this ecoregion. At the same time, 16,054 animal species have been described, 758 of which are chordates. 19 mammals, three birds, 15 reptiles and three amphibians are Caucasian endemics (Fourth National Report to CBD Georgia. (2010). Annex II)
[xx] Reference to the source is added. And the following text is added to endnotes: Data provided in the different official governmental documents and reports is based on 2003 indicators, and for the following period, it was based on the boundaries of the state forest fund defined by the Public Registry according to the regulation N299 adopted by the Government of Georgia on 4th August, 2011. However, it should be noted that there were several inaccuracies made during determination of boundaries, which obviously complicates general picture regarding forests in the country.
[xxi] A total of 300–500 thousand m^3 of timber resources are provided annually as firewood to the rural population. The local population also heavily relies on the plants, such as wild fruits, nuts, mushrooms, and wild plants (nettle, goosefoots, purslanes, and others). There are 1200 plant species utilized for medicinal reasons. Georgians have a wealth of knowledge on the use of herbal remedies in traditional folk medicine (Fifth National Report to CBD, 2015).
[xxii] The healthy forests ecosystems reduce the flow of rivers and protect reservoirs from overflowing.
[xxiii] The healthy forests ecosystems guarantee the protection against soil erosion, pest control, pollination of agricultural crops, etc.
[xxiv] Since 2012, the number of visitors has increased by 4 times and the record reached to 1,200,000 visitors in 2019. In 2021, the Agency of Protected Areas resumed visitor reception on May 26. In 5 months, the tourist record of 12 months of 2019 was fulfilled by almost 50%, hosting about 600,000 visitors (APA, 2022)
[xxv] The "Red List" represents a publication listing the conservation status of different taxa in a given geographic area (e.g. region, country, world). The series of publications produced by the International Union for the Conservation of Nature and Natural Resources (IUCN).
[xxvi] In 2020, the "Red List" of Georgia was updated, and as a result, the conservation status of numerous species was updated. The updated list should serve as the basis for the enforcement of the new Biodiversity Law prepared by the Ministry of Environment Protection and Agriculture (MEPA). Following the approval of the Biodiversity Law, the classification system and conservation mechanisms will be introduced, which are consistent with the guidelines of the International Union for Conservation of Nature (IUCN).
[xxvii] The greater the dependency, the greater is potential exposure to physical risks

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