2023

BSP DISCUSSION PAPER

The Impact of Biodiversity Loss on the Philippine Banking System: A Preliminary Analysis

Veronica B. Bayangos
Faith Christian Q. Cacnio
Ruffy A. Cruz
John Michael Rennie G. Hallig
Neil Fidelle G. Lomibao

Series
No.2023-03

BSP RESEARCH ACADEMY

The Impact of Biodiversity Loss on the Philippine Banking System: A Preliminary Analysis

Veronica B. Bayangos, Faith Christian Q. Cacnio, Ruffy A. Cruz,
John Michael Rennie G. Hallig, and Neil Fidelle G. Lomibao[a]

This version: 15 June 2023

ABSTRACT

The global economy is dependent on nature and the biosphere. Recent studies claim that the planet faces massive losses in nature and biodiversity. Such a significant loss creates risks to economies and financial systems. The Philippines is a biologically rich country that ranks high among biodiversity hotspots and is a global conservation area. This paper explores the extent to which Philippine banks are potentially exposed to risks from biodiversity loss through their lending portfolio and its impact on bank solvency using a stylized credit stress- testing exercise. Initial and preliminary results reveal that the potential direct impact of biodiversity loss on bank solvency appears to be modest. Crucially, the findings underscore the need to estimate the indirect dependencies on ecosystem services and the impact of biodiversity loss on credit and, consequently, bank solvency.

JEL classification	:	G21, Q57
Key words	:	biodiversity, ecosystem services, finance
Corresponding author	:	Veronica B. Bayangos, vbayangos@bsp.gov.ph

[a] Principal Researcher, Senior Researcher, Bank Officer IV (former), Researcher, Bank Officer II

The authors are grateful for the help extended by the Financial Supervision Sector (FSS): Deputy Governor Chuchi G. Fonacier, Assistant Governor Lyn I. Javier, Director Noel Guinto, and Deputy Director Rhodora M. Brazil-De Vera, and the officers and staff of the Supervisory Policy and Research Department (SPRD). We are equally thankful for the comments and feedback shared by Mr. Nepomuk Dunz and Mr. Ou Nie of the World Bank during the Mission Team meeting on 20 March 2023. The usual institutional disclaimer applies.

A. Introduction

The global economy is dependent on nature. The World Wildlife Fund (WWF) in 2022 reported that half of the global gross domestic product (GDP)—or US$44 trillion a year—comes from economic sectors that depend directly on the flow of goods and services generated by nature, such as food, raw materials, pollination, water filtration, and climate regulation. However, the planet faces a second crisis: nature and biodiversity loss. Menon (2022) argued that the nature crisis is no less threatening than the climate crisis but is much less appreciated, and much less is being done to mitigate it.

There are many definitions of biodiversity. In this study, the biosphere is defined as 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 of the planet's ecosystems (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem [IPBES] 2019). This means that biodiversity includes not only the diversity of genes and species but also the diversity of ecosystems. For instance, plants, algae, and many types of bacteria capture energy from the sun, which is why they are called primary producers. The energy they capture, along with other abiotic materials, flows through ecosystems and enables a wide range of natural processes, including biomass production, nutrient cycling, and water dynamics. A broader concept is of natural capital, which extends beyond nature as a source of raw materials for production to include the role of the environment and ecosystems in supporting human well-being by supplying important goods and services such as clean water, fertile soil, and genetic resources.

The degradation of nature— (otherwise known as loss of biodiversity—) and other nature-related risks are becoming increasingly relevant issues on the national and international policy agenda due to their relationship with first climate change agenda. Climate change contributes to nature and biodiversity loss through ocean acidification or by changing the living conditions of species. At the same time, nature loss is accelerating climate-related issues. Nature-based solutions, such as mangroves, can provide flood and storm protection (adaptation) and carbon sequestration (mitigation) at the same time. Biodiversity decline concerns many policymakers due to the relationship among biodiversity, ecosystem services, and human welfare. For example, agricultural crops can be derived from wild species; plants are often sources of natural medicines and contribute to prescription drug development (e.g., the rosy periwinkle found in Madagascar is the basis for medication used to treat Hodgkin's disease and childhood leukemia); wildlife provides essential nutrition and recreation; and ecosystems provide services for

humans (e.g., flood control, carbon sequestration, pollination of crops, and water filtration) (Congressional Research Service [CRS], 2021).

On 19 December 2022, the United Nations Biodiversity Conference (COP15) in Montreal, Canada, concluded with a landmark agreement to guide global action on nature through to 2030.[1] COP 15 resulted in the adoption of the Kunming-Montreal Global Biodiversity Framework (GBF). The GBF aims to address biodiversity loss, restore ecosystems, and protect indigenous rights. The plan includes concrete measures to help stop and reverse nature loss, including placing 30 percent of the planet and 30 percent of degraded ecosystems under protection by 2030. It also contains proposals to increase financing for developing countries.[2] Menon (2022) argued that authorities need financing for more sustainable supply chains, less disruptive infrastructure, and better farming practices that preserve yield while minimizing land degradation. Nature Conservancy estimates that funding needs may be as high as US$824 billion annually.

The Philippines is one of the world's 17 mega-diverse countries, which account for almost two-thirds of the earth's biological wealth and natural capital and host 70–80 percent of the world's biodiversity resources. On a per unit area, the Philippines has the greatest concentration of endemic species compared to other geographical jurisdictions in the world (Aquino-Gayao, 2014; DENR-Biodiversity Bureau [BMB], 2014). It hosts more than 52,170 known species, and more than half are considered endemic (DENR-BMB, 2014). There are at least 25 genera of plant species and 49 percent of terrestrial wildlife, which can only be found in the Philippines. The country ranks fifth in the number of plant species, accounting for 5.0 percent of the world's flora. It also ranks fourth in the world in bird endemism.

The Philippines has a rich and diverse marine ecosystem and is located at the apex of the Coral Triangle—the global center for marine biodiversity. It hosts nearly 10,000 marine species, about one-fifth of the world's total (Ani & Castillo, 2020). Specifically, the Philippines has 228 Key Biodiversity Areas (KBAs) or known habitats of 855 globally important species of plants, corals, mollusks, elasmobranchs, fishes, amphibians, reptiles, birds, and mammals in the country (DENR-BMD, 2016). Of these sites, 44 percent are classified as terrestrial, 34 percent are marine, and 22 percent are terrestrial and marine (Ambal et al., 2012). These KBAs are considered important sites for biodiversity conservation worldwide. These numbers could be underestimated, as the rate of discovery of new species

[1] United Nations Environment Programme (UNEP) press release, *COP 15 Ends With Landmark Biodiversity Agreement*, published 20 December 2022, accessible at https://www.unep.org/news-and-stories/story/cop15-ends-landmark-biodiversity-agreement

[2] The GBF identifies 23 targets to achieve by 2030, including: (A) effective conservation and management of at least 30 percent of the world's land, coastal areas, and oceans; (B) restoration of 30 percent of terrestrial and marine ecosystems; (C) reduction to near zero the loss of areas of high biodiversity importance and high ecological integrity; (D) halving of global food waste; (E) phasing out or reforming subsidies that harm biodiversity by at least US$500 billion per year, while scaling up positive incentives for biodiversity conservation and sustainable use; (F) mobilizing at least US$200 billion per year from public and private sources for biodiversity-related funding; (G) raising international financial flows from developed to developing countries to at least US$ 30 billion per year; and (H) requiring transnational companies and financial institutions to monitor, assess, and transparently disclose risks and impacts on biodiversity through their operations, portfolios, and supply and value chains.

in the Philippines is one of the highest in the world. Between 1997 and 2016, some 120 new species of wildlife fauna and 170 species of wildlife flora were discovered in the country. These numbers are still increasing, with discoveries made by the academe, researchers, and biodiversity-related funded projects.
The Philippines is a biologically rich country that ranks high among biodiversity hotspots and is a global conservation area together with the Himalayas, Polynesia-Micronesia, Atlantic Forest (i.e., Brazil, Paraguay, Argentina, and Uruguay), Indo-Burma, New Zealand, Japan, Sundaland, and Southwest and Eastern Australia. A large number of plant and wildlife species in the country are being destroyed and face extinction due to habitat loss, human activities, and climate change, among others (Ani & Castillo, 2020). It is estimated that there are at least 200 threatened species in the country. This extent of loss could have a severe impact on economic sectors dependent on biodiversity, which is also expected to result in losses for businesses providing services to these sectors. This phenomenon can be temporary or permanent, depending on whether the environmental degradation that leads to the loss is reversible through ecological restoration or resilience or effectively permanent (such as through land loss).

Several sectors, including clothing, timber, and fisheries, rely on the availability of biodiversity for their continuity and existence (Deloitte, 2022). In fact, all economic activity depends on natural capital, i.e., the stock of renewable and non-renewable resources (including biodiversity) providing a flow of ecosystem services to society. Some studies have argued that unsustainable production practices and human consumption have put nature in crisis, which has negative effects on different aspects of human well-being negatively. There are also indirect effects of biodiversity loss that can negatively impact the economic sectors. Habitat destruction and general biodiversity loss increase the risk of severe drought, newly emerging diseases, the disappearance of animal pollinators, and the collapse of fisheries and agricultural yield.

Global extinction has so far been proven to be irreversible (Dasgupta, 2021). While permanent global species loss is more dramatic than regional changes in species composition, minor changes from a healthy, stable state can have a dramatic influence on the food chain. Reductions in only one species can adversely affect the entire food chain, leading to an overall reduction in biodiversity. The main channel connecting biodiversity with economic systems is the ecosystem services provided by natural environments that help sustain economic production. Examples of ecosystem services include agricultural productivity gains through soil fertility, cleaning water streams and rivers, or pollinating plants and crops. The increasing use of biomass for energy production also highlights how these ecosystem services could have significant implications for economic sustainability.

Recent studies add to growing evidence that biodiversity loss could have significant economic and financial implications because the decline of ecosystem services poses physical risks for the economic actors that depend upon them (Toronto Centre, 2023). The Coalition of Finance Ministers for Climate Action[3] and

[3] The Coalition of Finance Ministers for Climate Action is a group of 80 Finance Ministries that have committed to aligning their economies with the goals of the Paris Agreement by implementing

the Network for Greening the Financial System (NGFS)[4] have recently taken significant steps to advance their understanding of nature-related risks. Following the publication of reports acknowledging the roles of their respective members in addressing nature loss and related risks, the two groups have agreed to collaborate and share information on this important topic. Engagement on this issue from the members of these two groups is important for the expected implementation of the post-2020 Global Biodiversity Framework following the Convention on Biological Diversity (CBD) COP15. Specifically, the NGFS has launched a Task Force on Biodiversity Loss and Nature-Related Risks as part of its 2022-2024 work plan, with the objective of mainstreaming the consideration of nature-related risks across NGFS work streams.

Biodiversity tends to help limit climate change but is, at the same time, negatively affected by it (Van Toor et al., 2020). Climate change and global warming can affect biodiversity in multiple ways. There is evidence that species can be, for instance, physiologically vulnerable to temperature spikes, increasing the probability of extinction and massive migrations. Pörtner et al. (2023) detailed why climate change and biodiversity loss are interdependent phenomena and must be tackled together. Specifically, biodiversity loss and climate change are both drivers and consequences of one another, tightly linked to human activities or demographic change and resulting in negative impacts on, among others, human health and wellbeing, as well as the functioning of society.

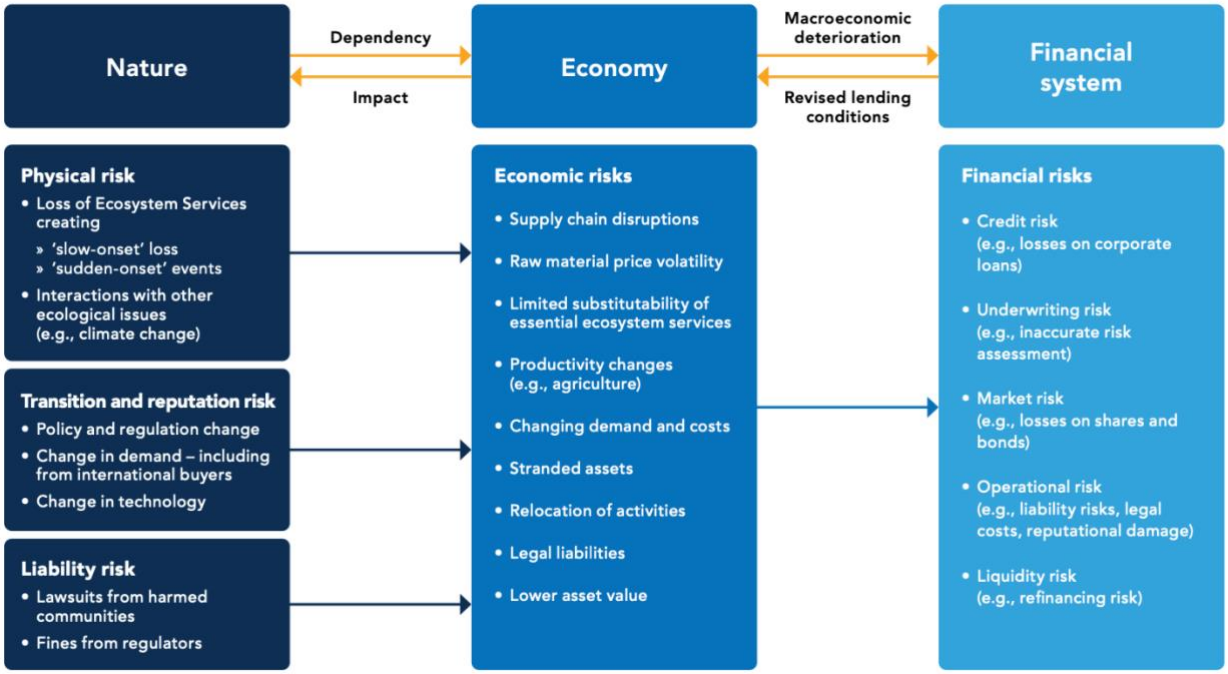
Recent studies emphasize that biodiversity loss, like climate change, is an external driver of financial risk, which poses physical, transition, and reputational risks to the financial sector (Fig. 1). Important components of this diagram are the dependency and impact of nature on the macroeconomy, which could lead to macroeconomic deterioration and changes in lending conditions. The degradation of biodiversity could lead to physical and transition risks that could feed through the economy. This could eventually pose risks to the financial system by reinforcing macroeconomic feedback effects (Dunz & Power, 2021). By financing clients through economic activities dependent on biodiversity, lending institutions are exposed to direct and indirect risks associated with biodiversity loss. Following World Bank and BNM (2022), this study defined exposure as the share of outstanding loans to sectors that are highly vulnerable, highly dependent, or highly impacting biodiversity. Due to the availability of data, the focus of the study is narrower since risks related to ecosystem services and natural assets such as water and forests are yet to be included. This study, therefore, covers only a portion of the environmental risk dimension in the Environmental, Social, and Government (ESG) framework for sustainable development.

the six Helsinki Principles. The Coalition was established in April 2019 and is co-chaired by the finance ministers of Finland and Indonesia.

[4] The NGFS, launched at the Paris One Planet Summit on 12 December 2017, is a group of central banks and supervisors who voluntary share best practices and contribute to the development of environment and climate risk management in the financial sector, and to mobilize mainstream finance to support the transition toward a sustainable economy. The NGFS brings together 121 central banks and supervisors from 87 jurisdictions and 19 observers. The NGFS is chaired by Mr. Ravi Menon, managing director of the Monetary Authority of Singapore.

Nevertheless, the schematic diagram below identified the risks to the financial system of biodiversity loss and other nature-related risks. Physical risks occur where clients are dependent on ecosystem services. These clients are likely to experience a decline in profitability as biodiversity decreases. Reduced profitability is expected to translate into a lower ability to meet financial commitments, such as loan repayments. Banks might observe higher default rates, loan loss provisions, capital requirements, and, ultimately, even lower new business rates.

Figure 1. From Nature-Related Risks (Including Biodiversity Loss) to Financial Risks



Sources: World Bank based on van Toor et al. (2020) and Svartzman et al. (2021)

Transition risks include new regulations and policies aimed at creating a more sustainable future, which might lead to restrictions on certain economic activities. These restrictions might involve significant costs or loss of business opportunities for clients, leading to decreased profitability for those clients. Customer preference for greener products might also result in reduced profitability and increased risk for financial institutions. Banks and financing companies with a negative impact on biodiversity and ecosystem services also expose financial institutions to reputational risks. This means that it is important for banks to include biodiversity, tangible transition, and physical risks, as well as indirect reputational risks, in their financial risk management systems.

Risks to the financial system could come from macroeconomic risks such as supply chain disruptions, productivity changes in the agriculture sector, changing demand, and additional costs, among others. These risks could eventually lead to credit, underwriting, market, operational, and liquidity risk.

However, the availability of data required to assess the expected impact of biodiversity loss remains a challenge, as the required data has often not been

captured by banks in the past. Data requirements include, for example, geographic areas with an increased risk of biodiversity disruption or information concerning business activities that negatively impact biodiversity. Next to data, there is also currently a lack of understanding and methodologies to assess how nature loss can have economic and financial impacts. Translating this shock into indicators that institutions such as central banks are used to work with (e.g., GDP, or inflation) is still very nascent at this point. So even if there is data, the ultimate question is what this means in economic terms. Things would be more complicated given the multiple dimensions to look into, such as biodiversity, soil health, and water cycles, and to project these into the future. It is clear from the discussions that biodiversity loss will have a critical impact on financial institutions and the economy if ignored.

This paper first determined the extent to which Philippine banks are potentially exposed to physical risks from biodiversity loss using bank-level data of universal and commercial banks and global data on biodiversity loss from 2010 to 2021. A historical perspective of banks' exposure is not entirely precise. However, this approach was used to see the variation in the impact of biodiversity loss on outstanding bank loans. The possible impact of biodiversity loss on bank solvency was then explored. It must be emphasized that not all risks caused by biodiversity loss were analyzed due to limitations in data.

Second, the paper focused on the initial impact of biodiversity loss on bank-level outstanding credit and the total effect on bank capital adequacy ratio through a stylized bank solvency stress test. The results in this paper therefore represent a lower boundary estimate for total exposure. The choice of the risks is based on the availability of balance sheets and biodiversity data. Moreover, the authors argued that the interaction between disaster or extreme weather events and biodiversity loss could reveal that the banking system is susceptible to even more exposure to nature-related risks in general. However, this study did not analyze the potential systemic risks of biodiversity loss. Nevertheless, the findings of this study contribute to the evolving discussions about the effect of environmental changes, particularly the loss of biodiversity, on the financial system.

Specifically, this study poses two questions: (A) Does biodiversity loss affect the Philippine banking sector? and (B) Does the loss of biodiversity impact bank solvency?

The rest of the paper is organized thus: Section B presents the state of biodiversity, risks, and challenges; Section C discusses emerging findings in a survey of related literature on biodiversity and the financial system; data and empirical methodology are presented in Section D; and Section E provides analysis of the initial results. Section F offers implications for BSP policy.

B. Recent Developments in the Philippines' Natural Capital and Biodiversity

State of natural capital assets in the Philippines. As mentioned in the previous section, an important broader concept pertains to natural capital. The Natural

Capital Protocol[5] defines natural capital as the "stock of renewable and non-renewable resources that combine to yield a flow of benefits to people." Risk stemming from natural capital depletion has been gaining traction within the finance sector. Many studies observe that as natural capital is depleted, it loses its capacity to support the ecosystem services[6] that businesses, economic activities, and broader society depend on. Depletion is defined in the Report as declines in the quantity and quality of stocks of natural capital assets, with indicators of depletion being selected to represent, as far as possible, variability in current relative rates of depletion in various locations. Different methodologies were applied in the terrestrial and marine environments, respectively, with datasets showing actual depletion used in the terrestrial analysis and an overlay of high stocks of natural capital and high levels of human pressure used in the marine analysis. However, through responsible management of natural capital, businesses have opportunities to reduce disruptions and associated risks in the economic regions in which they operate. Financial institutions, in turn, are exposed to and have a role in facilitating both negative and positive outcomes associated with natural capital.

Changes in natural capital—such as declines in soil quality and provision of fresh water, and biodiversity loss—bring outcomes and potential risks for economic industries. Businesses depend on, and impact, natural capital and are therefore inherently linked to the depletion, maintenance, and regeneration of natural capital. The 2020 World Economic Forum Nature Risk Rising report shows that over half of the world's GDP is moderately or highly dependent on natural capital.

In the Philippines, the National Economic and Development Authority the Philippine Statistics Authority (PSA), and the Department of Environment and Natural Resources (DENR) jointly developed and released the Roadmap to Institutionalize Natural Capital Accounting (NCA) in June 2022. The release of the Roadmap aims to provide strategic guidance on the national implementation of NCA from 2022 to 2040. It also presents critical activities, milestones, and outputs for each planning period to fully institutionalize and integrate NCA, including the valuation of ecosystem services in the government's planning, investment decisions, and policymaking process.[7] The Roadmap has six components: (A) compilation of natural capital accounts; (B) estimation of natural capital–adjusted macroeconomic indicators; (C) policy use and applications; (D) data management systems; (E) capacity development; and (F) dissemination.

The institutionalization of the NCA highlights the significant economic benefits of biodiversity and ecosystem services. In 2004, the national list of threatened faunal species was established. It included 42 species of land mammals, 127 species of birds, 24 species of reptiles, and 14 species of amphibians. In addition, the Philippines has at least 3,214 species of fish, of which 121 are endemic, and 76 are threatened. Among the species identified as critically endangered are the tamaraw

[5] The Natural Capital Protocol is a decision-making framework that enables organizations to identify, measure, and value their direct and indirect impacts and dependencies on natural capital.
[6] The Millennium Ecosystem Assessment defines ecosystem services as "benefits people obtain from ecosystems."
[7] The Roadmap also identified the priority ecosystem sites for ecosystem accounting in the Philippines.

(*Bubalus mindorensis*), dugong (*Dugong dugon*), Philippine eagle (*Pithecophaga jefferyi*), Philippine crocodile (*Crocodylus mindorensis*), and Philippine deer (*Rusa marianna*) (DENR, 2019). Subsequently, a national list of threatened plant species was established in 2007 through an administrative order of the DENR. The list classified 99 species as critically endangered, 187 as endangered, 176 as vulnerable, and 64 as threatened. These include yakal (*Shorea astylosa*), waling-waling (*Vanda sanderiana*), giant staghorn fern (*Platycerium grande*), tungkod-langit (*Helminthostachys seylanica*), and malatubo (giant orchid; *Grammatophyllum speciosum*) (DENR, 2017).

The Philippines is an archipelago of approximately 7,641 islands with a total coastline of 36,289 kilometers or 22,548.94 miles. More than 60 percent of the country's population live in coastal areas, as major cities and large industrial areas are located near the sea DENR-Biodiversity Management Bureau, (DENR-BMB, 2014). Many of the country's productive natural ecosystems are on the coast, and many Filipino households source their food and livelihood from these areas.

Aside from coastal areas, the Philippines also benefits significantly from watersheds and river basins. These offer ecosystem services that support economic activities such as agriculture, forestry, ecotourism, and recreation. For example, a watershed with ample forest cover provides water that irrigates lowland agriculture, prevents soil erosion and siltation of coasts and bodies of water, and sustains the supply of surface and groundwater for domestic use (CBD, n.d.). Forest ecosystems provide ecological services addressing agriculture, industries, water, and power needs. As a primary sector of the economy, the agriculture, fisheries, and forestry (AFF) sector derives significant benefits from biodiversity and its ecosystem services. The AFF sector is a key contributor to Philippine economic growth. Between 2010 and Q2 2022, the AFF sector accounted for 12.8 percent of the country's GDP and employed almost a third (i.e., 30 percent) of the workforce.

Some studies have tried to estimate the economic value of ecosystem services in the Philippines (Mercado, 2016). Table 1 presents a compilation of the valuation of the country's ecosystem services.

Table 1. Estimated Values of Philippine Biodiversity and Ecosystem Services

Ecosystem service	In PHP billion (as of December 2016)	Share in estimated total value of ecosystem service (percent)
Timber and fuel wood production	1.1	0.05
Water provision	50.9	2.3
Ecotourism	157.0	7.0
Carbon offset	453.0	20.2
Flood prevention	41.0	1.8
Soil erosion	10.0	0.4
Fishery production	111.0	4.9
Crop production	1,416.0	63.0
Mangrove	7.4	0.33
Total	2,247.40	100.00

Sources: Compiled by the Biodiversity Finance Initiative (BIOFIN); Authors

Crop production generates the highest value among the ecosystem services, followed by carbon offset, ecotourism, and fishery production. The value of crop production is estimated at ₱1,416 billion, equivalent to almost 63 percent of the total estimated value of ecosystem services covered in these studies. Carbon offset, which involves the reduction of greenhouse gas (GHG) emissions to counter emissions that occur elsewhere, generates a total value of ₱453 billion or 20.2 percent of the total value of ecosystem services. It is worth noting that the Philippines targets a 75 percent reduction in GHG emissions by 2030 as part of its commitment to the Paris Agreement on climate change. Ecotourism and fish production are the other ecosystem services valued at ₱157 billion (or 7.0 percent of total services) and ₱111 billion (or 4.9 percent of total services), respectively.

In a more recent study, Tamayo et al. (2018) assessed the value of the ecosystem services derived from Philippine reefs. They estimated the economic values of fisheries, tourism, and biodiversity generated from reefs across the country's 15 regions. Based on their estimates, the total economic value or TEV of Philippine reefs and coastal marine resources was US$3.65 billion/year (₱192.1 billion)[8] or roughly US$140,000/km^2/year (₱7.4 million/km^2/year).

The 2018 Input-Output (IO) table shows a sectoral view of the contribution of ecosystem services to the economy, with a focus on three key industries: AFF; mining and quarrying; and electricity, steam, and water and waste management. These are economic sectors that provide various ecosystem services to other industries. Table 2 presents the distribution of output from these sectors based on the 2018 I-O transactions table.

The table shows that the AFF sector supplied ₱2,370.6 billion of intermediate goods and services to the other industries for their production needs. This accounts for 13 percent of total intermediate goods and services used in the economy. Looking at the AFF subsectors, crop production reached ₱1,005.8 billion (5.5 percent of total intermediate demand); livestock was at ₱887.1 billion (4.9 percent); forestry and logging were at ₱7.2 billion (0.04 percent); and fishing and aquaculture were at ₱254.2 billion (1.4 percent).

The AFF sector is the economy's largest provider of intermediate goods and services. This is not surprising, given that the AFF is a primary sector of the economy. It is a key source of raw materials and inputs used for production by other industries in the economy. The AFF sector is connected to almost all industries, either directly or indirectly. Thus, other sectors of the economy have a high dependency on AFF.

Mining and quarrying produced ₱468.3 billion worth of intermediate inputs, equivalent to 2.6 percent of total intermediate demand. Steam and water supply provided 0.1 percent and 0.4 percent of total intermediate needs, amounting to ₱16.3 billion and ₱74.7 billion, respectively. Overall, the AFF sector's output reached ₱3,461 billion or 9.5 percent of the total output in the economy. Crop production yielded ₱1,184.2 billion (3.2 percent of total output); livestock ₱1,424.7 billion (3.9 percent); forestry and logging ₱7.2 billion (0.02 percent); and fishing and

[8] Based on the average peso-dollar rate for 2018 of ₱52.661/US$1.

aquaculture ₱604.7 billion (1.7 percent). Mining and quarrying accounted for ₱245.2 billion (0.7 percent of total output), while steam contributed ₱16.5 billion (0.05 percent) and water supply, ₱123.0 billion (0.3 percent).

Another interesting aspect not covered in this analysis is the spatial linkages. The agriculture sector is usually more located in rural areas, whereas the service sectors and several industries are mostly located in the larger cities, particularly in Metro Manila. In the absence of data and information, this could be an area for future research.

Households are the largest consumers of AFF's final output at ₱681.7 billion, equivalent to 19.7 percent of the sector's total output. They also have the highest demand for water supply and steam at 37.9 percent and 0.7 percent of total output, respectively. In terms of exports, the AFF sector supplied 2.6 percent of its total output abroad, amounting to ₱88.4 billion. The mining and quarrying sector exported a larger proportion of its total output (32.6 percent), valued at ₱80.04 billion.

Nonetheless, some ecosystem services are not properly valued. The value of ecosystem services is often estimated using the amount people are willing to pay to preserve or enhance the services. However, this may not apply to some ecosystem services. For instance, ecosystem services such as timber or agricultural produce are traded in the markets. However, recreational activities such as trekking through the woods, bird watching, and deep-sea diving are not bought and sold in markets (DENR–BMB, 2016). Thus, consumers do not directly pay for many ecosystem services. The undervaluation of ecosystem services is one of the main reasons cited for the heedless use of biodiversity resources in the Philippines. The real value of biodiversity to the economy and society is not fully accounted for and appreciated.

Recognizing this, the NCA Roadmap emphasizes outlining the interactions of economic activity with the environment, which will lead to more informed and better economic decisions. For example, allowing widespread logging activities could translate to higher timber production and revenues for the economy. However, the economic benefit would only be temporary, and in the long run, healthy forestlands are crucial to a well-functioning economy.

Table 2. Ecosystem Services and Economic Sectors[1]

(Based on the 2018 Input-Output Accounts of the Philippines)
(in PhP millions)

Description	Agriculture, forestry, and fishing	Industry	Services	**Total intermediate demand**	Household final consumption expenditure	Government final consumption expenditure	Construction	Durable equipment	Breeding stocks and orchard development	Intellectual property products	Changes in inventories	Valuables	Exports of goods and services	Imports of goods and services	**Total final demand**	**Total output**
Agriculture, forestry, and fishing	996,184	1,341,703	32,670	**2,370,557**	681,704	4,199	0	0	395,724	88	-1,346	31	88,379	78,355	**1,168,780**	**3,460,982**
Crop production	46,278	951,044	8,489	**1,005,810**	165,535	406	0	0	7,173	38	-1,012	1	80,649	74,427	**252,789**	**1,184,172**
Livestock	707,991	174,904	4,218	**887,114**	149,727	2,222	0	0	388,368	0	-341	1	703	3,144	**540,681**	**1,424,651**
Forestry and logging	103	7,041	12	**7,155**	10	1	0	0	0	0	0	0	5	13	**17**	**7,159**
Fishing and aquaculture	28,527	206,199	19,499	**254,225**	342,787	1,425	0	0	2	50	3	29	6,490	330	**350,785**	**604,681**
Support activities to agriculture, forestry, and fishing	213,286	2,513	452	**216,252**	23,644	146	0	0	181	0	4	0	533	442	**24,508**	**240,318**
Mining and quarrying	44	466,465	1,761	**468,270**	1,250	183	0	0	0	16,255	-3,063	24	80,039	317,789	**94,688**	**245,169**
Electricity, steam, water and waste management	23,680	334,689	279,209	**637,579**	228,099	30,208	0	0	0	1,368	0	0	0	0	**259,676**	**897,255**
Electricity	20,729	273,639	249,427	**543,796**	170,376	29,397	0	0	0	400	0	0	0	0	**200,173**	**743,969**
Steam	14	16,148	175	**16,336**	119	21	0	0	0	0	0	0	0	0	**140**	**16,475**
Water supply	2,823	43,561	28,328	**74,710**	46,596	723	0	0	0	938	0	0	0	0	**48,257**	**122,967**
Sewerage and waste management and remediation activities	114	1,343	1,280	**2,737**	11,008	68	0	0	0	30	0	0	0	0	**11,106**	**13,843**
Total intermediate consumption	**1,698,365**	**7,450,210**	**181,917**	**18,274,281**	**13,250,084**	**2,199,637**	**2,939,786**	**1,527,020**	**397,760**	**118,780**	**(26,944)**	**2,703**	**5,518,573**	**7,662,209**	**25,927,400**	**36,539,472**
Compensation of employees	580,692	959,037	98,666	**6,297,084**												
Gross operating surplus	1,135,500	2,283,938	265,198	**10,583,750**												
Taxes less subsidies on production and imports	46,424	245,357	47,161	**1,384,356**												
Total primary inputs	**1,762,616**	**3,488,331**	**411,025**	**18,265,190**												
Total inputs	**3,460,982**	**10,938,541**	**592,942**	**36,539,472**												

[1/] The 2018 Input-Output transactions table is comprised of 16 industries. These industries were put together into the three main sectors of the economy, as follows: (A) agriculture, forestry, and fishing; (B) industry (i.e., mining and quarrying, manufacturing, electricity, steam, water and waste management, and construction); (C) services (i.e., wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities, information and communication, financial and insurance activities, real estate and ownership of dwellings, professional and business services, public administration and defense; compulsory social activities; education; and human health and social work activities; and other services). The I-O transactions table is as of December 2021.

Source: PSA

Biodiversity has evolved in the Philippines. DENR-BMB (2015) reported that agricultural biodiversity (or agrobiodiversity) is an important component of Philippine biodiversity. Agrobiodiversity is the **result of the interaction between the environment, genetic resources, and management systems and practices used by culturally diverse people,** and, therefore, land and water resources are used for production in different ways (FAO, 1999). Thus, agrobiodiversity encompasses the variety and variability of animals, plants, and microorganisms necessary for sustaining key functions of the agroecosystem, including its structure and processes for and in support of food production and security.

City biodiversity exposes urban residents to an environment or landscape which facilitates their appreciation for nature. It provides opportunities for recreation, health, relaxation, and community cohesion. However, there are principal pressures on Philippine biodiversity. Biodiversity loss in the Philippines has been mainly attributed to the continuous destruction of habitats and ecosystems. Degradation renders the habitat unsuitable for supporting species and life forms. Since tropical forests are key habitats, loss of habitat due to deforestation is a significant driver of biodiversity loss in the country (DENR–BMB, 2016). Over the past 100 years, the deforestation rates averaged about 150,000 hectares per year (Rebugio et al., 2005). Between 1934 and 1990, the Philippines was estimated to lose 10.9 million hectares of forest cover. The country is said to have lost almost 93 percent of its original forest cover since the 1900s (Ong et al., 2002). Moreover, of the 450,000 hectares of mangrove areas that the country had in the early 1900s, only 140,000 hectares were left by the turn of the century (Lim, 2014). The Philippines' coral reef area is also considered one of the largest in the world at an estimated 22,500 sq. km. However, by the 1980s, 40 percent of the country's coral reef cover was already in poor condition; this increased further to 53 percent by the mid-2000s. The area categorized as an excellent coral cover declined to less than 1 percent (Lim, 2014).

The DENR-BMB (2016) identified key factors contributing to deforestation and continuing destruction of habitats. These major threats include:

a. Overexploitation typically leads to exhaustion, particularly by excessive forestry, fishing, and hunting (DENR-BMB, 2015). Illegal logging is a major pressure point. Although a ban has helped curb logging activities, illegal logging activities persist. Based on 2010 satellite images, the Philippines' total forest cover is estimated at 6.84 million hectares. Open forest accounted for almost 67.2 percent of the total forest cover, or 4.6 million hectares (DENR-FMB, 2012).
b. Overlapping mining claims and rights with defined protected areas (PAs) and ancestral lands, including those intended as conservation areas. Most of the priority conservation areas in the country have huge mineral reserves, which result in conflicts with prescribed land uses and objectives. These, in turn, threaten ecological sustainability.
c. Overpopulation pressures. Given its limited land base, the country's expanding population (i.e., an annual growth rate of 1.31 percent as of 2021)

has led to the conversion of forest areas into agricultural lands and settlements. The lack of a comprehensive national land use policy has also led to diverging land uses and indiscriminate land conversion.

d. Untenable production and consumption of medicinal and ornamental plants and overharvesting wild animals for trade and domestic use. These activities have contributed to habitat degradation and significant reductions in species populations.
e. Introduction of invasive alien species has also affected biodiversity, particularly in wetlands.
f. Adverse effects of climate change. Changes in the timing of biological events, species distribution, and plant and animal behavior, as well as increased frequency and intensity of occurrence of pests and diseases, have been identified as direct effects of climate change. Climate change also increases the vulnerability of species to extinction and could lead to potential losses of net productivity of ecosystems.

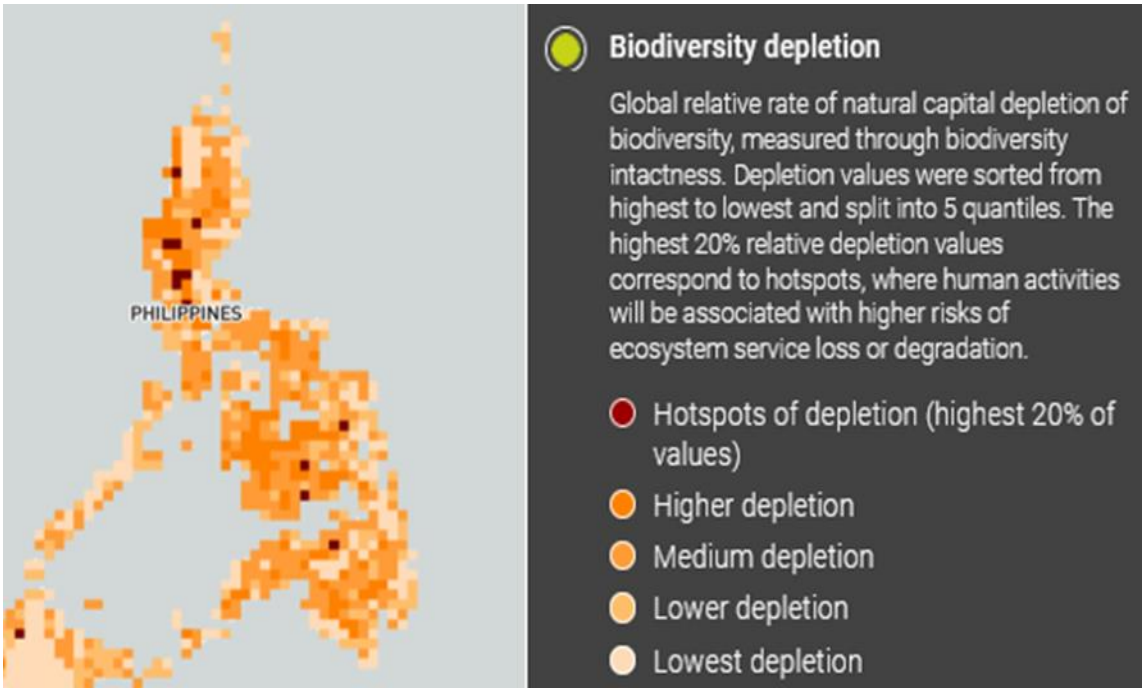
Indications of potential depletion of Philippine biodiversity based on global data. The UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) Report (2021)[9] revealed that only a handful of spots in the Philippines could be considered hotspots of biodiversity depletion (at the top of the 20 percent quintile). However, a vast portion of the Philippines is categorized at a higher or medium biodiversity depletion (Fig. 1). In collaboration with the UN Principles for Responsible Investment (PRI), UNEP-WCMC developed maps to showcase global hotspots of relative natural capital depletion, made available for visualization in ENCORE (Exploring Natural Capital Opportunities, Risks, and Exposure). The drivers of environmental change that ENCORE covers are diseases, drought, earthquakes, and fire, among others.[10]

Hotspots correspond to areas within the top 20 percent of relative depletion values for natural capital assets globally. This information will help investors identify potential exposures in their portfolios to natural capital depletion in certain geographies. The UNEP-WCMC report finds that, although the Philippines is not part of the largest global hotspots of biodiversity depletion, such as the Great Plains in North America, the Southern cone of South America, Southern Africa, Central Asia, and Australia, biodiversity depletion in the Philippines poses larger challenges. The market, credit, and operation risks of losing natural capital in these locations should be a concern. It must be noted that changes in natural capital, such as declines in soil quality, availability of fresh water, and loss of biodiversity, create business risks and outcomes

[9] The UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) is a global center of excellence in biodiversity. The Centre operates as a collaboration between the UNEP and the UK-registered charity WCMC.

[10] Other drivers covered by ENCORE are flooding, habitat modification, human modification of genetic material, human movement, industrial or domestic activities, industrial or domestic construction, intensive agriculture and aquaculture, invasive species, landslides, ocean acidification, ocean and current circulation, overfishing, overharvesting, overhunting, pests, pollution, population changes, sea level rise, sea surface temperatures, storms, volcanoes, water abstraction, and weather conditions. (Source: ENCORE: Drivers of environmental change at https://encore.naturalcapital.finance/en/data-and-methodology/drivers)

Figure 2. Biodiversity Depletion in the Philippines

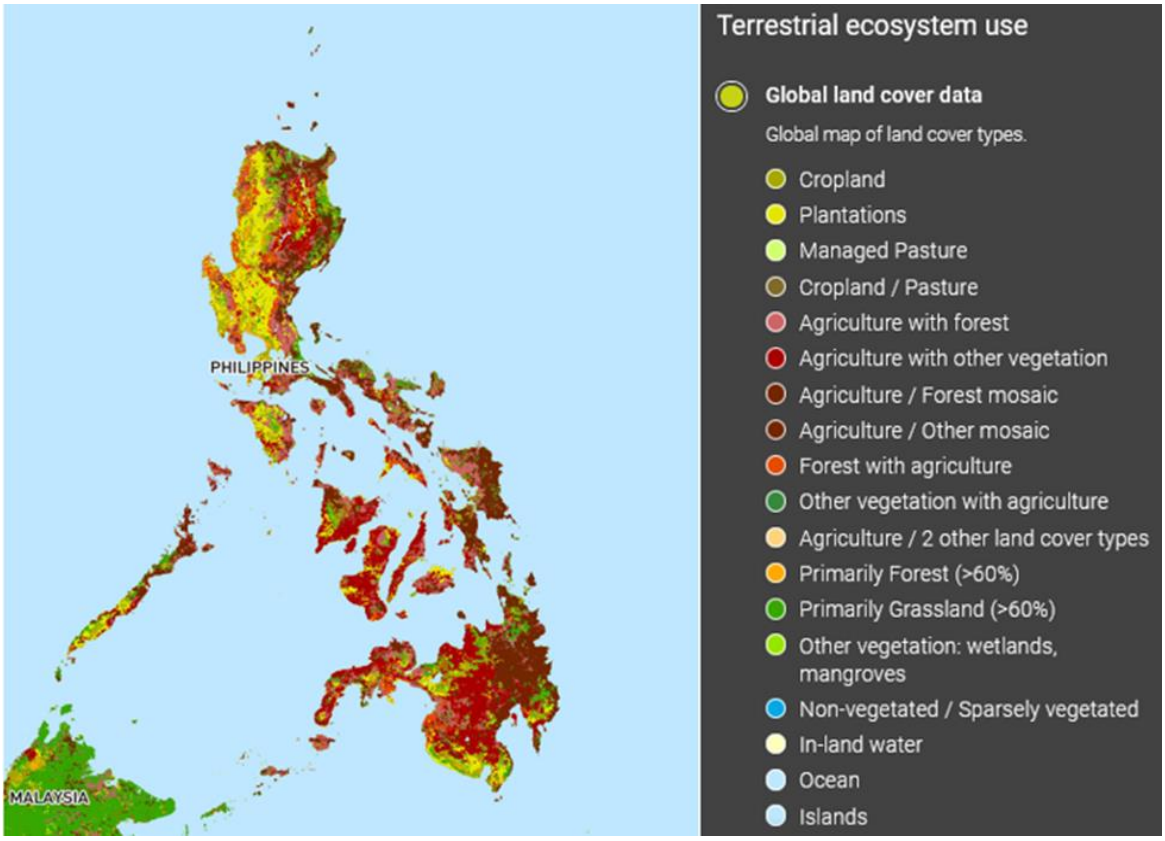


Source: ENCORE

Hotspots appear to overlap with terrestrial biomes. The overlap of hotspots of atmosphere depletion with the different biomes is discussed in the UNEP-WCMC report. Global hotspots of natural capital depletion span 14 terrestrial biomes, with 10 having over 50 percent of their area overlapping with a hotspot of depletion for at least one natural capital asset. For instance, *Tropical and Subtropical Grasslands, Savannas, and Shrublands*, one of the largest biomes in the world (over 21 million km^2, found across South America, Central and Southern Africa, and Australia) had a 94 percent overlap with hotspots of natural capital depletion. By contrast, *Boreal Forests and Taiga* (found in Canada, Alaska, Russia, and Scandinavia) had the least overlap (14 percent). Globally, the four biomes with the greatest overlap—*Temperate Broadleaf and Mixed Forests*; *Montane Grasslands and Shrublands*; *Mediterranean Forests, Woodlands, and Scrub*; and *Tundra*—are predominantly found in the Northern Hemisphere.

Figure 2 shows the overlapping of biodiversity depletion with terrestrial ecosystem use in the Philippines. Most locations with medium to hotspot levels of biodiversity depletion are used for commercial or business purposes, such as cropland, plantations, and various agricultural activities. Biodiversity depletion in these areas poses risks to enterprises engaged in said activities as compromised delivery of ecosystem services, such as pollination, may adversely affect crop production. On the other hand, these locations may provide an opportunity for investments by producing positive outcomes by stopping or mitigating losses through a transition toward nature-positive activities.

Figure 3. Terrestrial Ecosystem Uses in the Philippines



Source: ENCORE (2021)

Tables 3a and 3b present the hotspot regions and those with medium and high probabilities of depletion. Hotspots of depletion are Regions I, II, III, VII, VIII, X, and the National Capital Region (NCR). The hotspot of depletion in Region I lies on cropland/pasture; in Region II on agriculture with forest and agriculture with other vegetation; in Region III on plantations and croplands; in Region VII on agriculture with forest and agriculture with other vegetation; in Region VIII on agriculture with forest, agriculture/forest mosaic, and other vegetation with agriculture; in Region X on agriculture with other vegetation; and in the NCR on primarily forest (>60 percent) and cropland.

Table 3a. Regions with Hotspot, High, and Medium Probability of Biodiversity Depletion

No.	Region	Region name	Hotspot	High depletion rate	Medium depletion rate
1	NCR	National Capital Region	X		
2	CAR	Cordillera Administrative Region		X	

3	I	Ilocos	X	X	
4	II	Cagayan Valley	X		X
5	III	Central Luzon	X	X	X
6	IV-A	CALABARZON		X	X
7	IV-B	MIMAROPA		X	X
8	V	Bicol Region			X
9	VI	Western Visayas		X	X
10	VII	Central Visayas	X	X	X
11	VIII	Eastern Visayas	X		X
12	IX	Zamboanga Peninsula		X	X
13	X	Northern Mindanao	X	X	X
14	XI	Davao Region		X	X
15	XII	SOCCKSARGEN		X	X
16	XIII	CARAGA		X	X
17	BARMM	Bangsamoro Autonomous Region in Muslim Mindanao		X	

Sources: ENCORE; Authors

Table 3b shows regions with locations considered to have high depletion: in Region I these lie on agriculture with forest, agriculture with other vegetation, and cropland/pasture; in the Cordillera Administrative Region (CAR) on agriculture with forest, agriculture/forest mosaic, cropland, and primarily grassland (>60 percent); in Region II on agriculture with forest, agriculture/forest mosaic, forest with agriculture, and primarily grassland (>60 percent); in Region III on plantations with patches of cropland, forest with agriculture, other vegetation with agriculture, and primarily grassland (>60 percent); in Region IV-A on agriculture with forest, and agriculture/forest mosaic; in Region IV-B on agriculture with forest, agriculture/other mosaic with patches of plantations, and other vegetation with agriculture; in Region VI on agriculture with other vegetation, agriculture with forest, forest with agriculture, and plantations; in Region VII on agriculture with other vegetation, agriculture with forest, plantations, and agriculture/other mosaic; in Region IX on agriculture with other vegetation, forest with agriculture, agriculture/forest mosaic, plantations, and cropland; in Region X on primarily grassland (>60 percent), plantations, agriculture with forest, and other vegetation with agriculture; in the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM) on agriculture with forest, agriculture/other mosaic, agriculture with other vegetation, and plantations; in Region XI mainly on agriculture/other mosaic, and agriculture with other vegetation with portions of primarily grassland (>60 percent), plantations, and cropland; in Region XII on plantations, cropland, agriculture with other vegetation, and primarily grassland (>60 percent); and in Region XIII on agriculture/forest mosaic, agriculture with forest, and primarily grassland (>60 percent).

Table 3b. Areas with Hotspot, High, and Medium Probability of Biodiversity Depletion

No.	Region	Region name	Hotspot	High depletion rate	Medium depletion rate
1	NCR	National Capital Region	Forest and cropland		
2	CAR	Cordillera Administrative Region		Agriculture with forest, agriculture/forest mosaic, cropland, and primarily grassland	
3	I	Ilocos	Cropland/pasture	Agriculture with forest, agriculture with other vegetation, and cropland/pasture	
4	II	Cagayan Valley	Agriculture with forest and agriculture, and other vegetation	Agriculture with forest, agriculture/forest mosaic, forest with agriculture, and primarily grassland	Agriculture/forest mosaic, agriculture with other vegetation, agriculture with forest, forest with agriculture, plantations, and cropland
5	III	Central Luzon	Plantations and cropland	Mainly plantations with patches of cropland, forest with agriculture, other vegetation with agriculture, and primarily grassland	Plantations, cropland, agriculture with forest, forest with agriculture, agriculture/forest mosaic, and primarily grassland
6	IV-A	CALABARZON		Agriculture with forest, and agriculture/forest mosaic	Agriculture with forest, and agriculture/forest mosaic
7	IV-B	MIMAROPA		Agriculture with forest, and agriculture/other mosaic with patches of plantations, and other vegetation with agriculture	Plantations, cropland, agriculture with forest, agriculture/forest mosaic, primarily grassland, and forest with agriculture
8	V	Bicol Region			Agriculture with forest, agriculture/forest mosaic, agriculture with other vegetation, plantations, cropland, and primarily grassland
9	VI	Western Visayas		Agriculture with other vegetation, agriculture	Agriculture/forest mosaic,

				with forest, forest with agriculture, and plantations	agriculture with other vegetation, agriculture with forest, plantations, and cropland
10	VII	Central Visayas	Agriculture with forest, and agriculture with other vegetation	Agriculture with other vegetation, agriculture with forest, plantations, and agriculture/other mosaics	Agriculture with other vegetation, agriculture/forest mosaic, agriculture with forest, plantations, cropland, and primarily grassland
11	VIII	Eastern Visayas	Agriculture with forest, agriculture/forest mosaic, and other vegetation with agriculture		Agriculture/forest mosaic with enclaves of agriculture with forest, primarily grassland and plantations
12	IX	Zamboanga Peninsula		Agriculture with other vegetation, forest with agriculture, agriculture/forest mosaic, plantations, and cropland	Agriculture with other vegetation, agriculture with forest, agriculture/forest mosaic, primarily grassland and plantations
13	X	Northern Mindanao	Agriculture with other vegetation	Primarily grassland, plantations, agriculture with forest, and other vegetation with agriculture.	Agriculture with other vegetation, and agriculture/forest mosaic, managed pasture, and primarily grassland and forest with agriculture
14	XI	Davao Region		Mainly on agriculture/other mosaic, and agriculture with other vegetation with portions of primarily grassland, plantations, and cropland	Agriculture with other vegetation, and agriculture/forest mosaic with patches of cropland, plantations, agriculture with forest, and primarily grassland
15	XII	SOCCKSARGEN		Plantations, cropland, agriculture with other vegetation, and primarily grassland	Agriculture with other vegetation with portions of plantations,

					cropland, agriculture with forest, and agriculture/forest mosaic
16	XIII	CARAGA		Agriculture/forest mosaic, agriculture with forest, and primarily grassland	Agriculture/forest mosaic, agriculture with other vegetation, agriculture with forest, primarily grassland and plantations
17	BARMM	Bangsamoro Autonomous Region in Muslim Mindanao		Agriculture with forest, agriculture/other mosaic, agriculture with other vegetation, and plantations	Agriculture with forest, agriculture/forest mosaic, and primarily grassland

Sources: ENCORE; Authors

Table 3b also shows regions with locations categorized considered to have medium depletion: in Region II these lie on agriculture/forest mosaic, agriculture with other vegetation, agriculture with forest, forest with agriculture, plantations, and cropland; in Region III on plantations, cropland, agriculture with forest, forest with agriculture, agriculture/forest mosaic, and primarily grassland (>60 percent); in Region IV-A on agriculture with forest, agriculture/forest mosaic, plantations, and primarily grassland (>60 percent); in Region IV-B on plantations, cropland, agriculture with forest, agriculture/forest mosaic, primarily grassland (>60 percent), and forest with agriculture; in Region V on agriculture with forest, agriculture/forest mosaic, agriculture with other vegetation, plantations, cropland, and primarily grassland (>60 percent); in Region VI on agriculture/forest mosaic, agriculture with other vegetation, agriculture with forest, plantations, and cropland; in Region VII on agriculture with other vegetation, agriculture/forest mosaic, agriculture with forest, plantations, cropland, and primarily grassland (>60 percent); in Region VIII mainly on agriculture/forest mosaic with enclaves of agriculture with forest, primarily grassland (>60 percent), and plantations; in Region IX on agriculture with other vegetation, agriculture with forest, agriculture/forest mosaic, primarily grassland (>60 percent), and plantations; in Region X on agriculture with other vegetation, and agriculture/forest mosaic, managed pasture, primarily grassland (>60 percent), and forest with agriculture; in the BARMM on agriculture with forest, agriculture/forest mosaic, and primarily grassland (>60 percent); in Region XI mainly on agriculture with other vegetation, agriculture/forest mosaic with patches of cropland, plantations, agriculture with forest, and primarily grassland (>60 percent); in Region XII primarily on agriculture with other vegetation, with portions of plantations, cropland, agriculture with forest, and agriculture/forest mosaic; and in Region XIII on agriculture/forest mosaic, agriculture with other vegetation, agriculture with forest, primarily grassland (>60 percent), and plantations.

Identification of hotspots of depletion and how these hotspots overlap with the terrestrial ecosystem not only indicate areas where investors should be particularly mindful of the market, credit, and operational risks associated with loss of natural capital but also where investment could have a positive outcome through a transition to nature-positive activities. On the one hand, biodiversity depletion in these areas poses risks to enterprises engaged in said activities, as compromised delivery of ecosystem services such as pollination may adversely affect crop production. Pollinators (e.g., bees, wasps, butterflies, bats, and birds) generate much-needed biological activities to sustain biodiversity and food production, a decline that would threaten pollination-dependent crops and adversely affect the diversity of plant species (ASEAN Center for Biodiversity, 2017).[11] On the other hand, these locations may provide an opportunity for investments by producing positive outcomes by stopping or mitigating such losses through a transition toward nature-positive activities.

These considerations can feed into further research and analyses required by central banks and financial regulators to understand the regeneration potential for stocks of these natural capital assets or how biodiversity could be protected, the relevant potential indicators of both natural assets and biodiversity, risks associated with these indicators, and future policy implications for central banks and financial supervisors.

C. A Survey of Literature in Assessing Potential Financial Impacts from Biodiversity Loss

Recent studies on nature-related risks, such as biodiversity loss and deforestation, remain relatively scant. Francia (2020) observed that biodiversity is declining at its fastest rate in history and said decline can be traced to factors such as land conversion, pollution, and human-induced climate change. The study by Johnson et al. (2021) also developed the framework for the first global nature-economy model. The framework integrates select ecosystem services into a computable general equilibrium (CGE) model. The framework allows an assessment of the link between the decline of select ecosystem services—pollination of crops by wild pollinators, climate regulation from carbon storage and sequestration, provision of food from marine fisheries, and provision of timber—and the performance of key sectors that rely on these services, such as AFF and related industries.

The primary channel linking biodiversity and the economic system is ecosystem services, which provide natural environment services to help drive economic activities. Showing the Dutch financial institutions' indirect dependency on ecosystem services, Van Toor et al. (2020) discovered that €510 billion—or 36 percent of Dutch financial institutions' total portfolio—in investments by the Netherlands' financial institutions are considered to be high or very highly dependent on one or more ecosystem services. Due to the association between

[11] *ASEAN Biodiversity Outlook 2* (2017), ASEAN Center for Biodiversity

biodiversity losses and financial stability, the Banque de France (2021) estimates *physical risk* on the measure of dependencies on different ecosystem services of firms whose securities are held by French financial companies and *transition risk* by measuring the biodiversity impact or footprint of firms whose securities are also held by French financial companies through direct activities or upstream value chains. Using quantitative estimates of dependencies and effects on biodiversity by the French financial system, Svartzman et al. (2021) discovered that 42 percent of the values of securities in the hands of French financial institutions originate from issuers considered as highly or very highly dependent on one or more ecosystem services.

To measure the impact of economic activities on biodiversity and, conversely, biodiversity-related financial risks, the NGFS (2022) discussed emerging methodologies that include, among others, measuring biodiversity footprints, exposure to physical risk from biodiversity loss (Van Toor et al., 2020), assessing dependencies and impacts on ecosystem services by securities held by the financial sectors (Svartzman et al., 2021), and exposure of banks to biodiversity loss through lending to non-financial corporations (Calice et al., 2021).

The impact of biodiversity loss in the insurance industry cannot be discounted. Augeraud-Veron et al. (2017) used a stylized dynamic model that motivates biodiversity conservation, which performs a crucial role as insurance against agricultural productivity fluctuations. The Swiss Re Institute (2020) developed the Biodiversity and Ecosystem Services (BES) Index, a color-coded map indicating the state of different ecosystem services in order to provide information to financial and re/insurance markets for risk protection and capital provisions to clients.

As previously mentioned, the ENCORE database contains maps that help visualize areas considered hotspots relative to natural capital depletion on a global scale. Natural capital is "the stock of renewable and non-renewable resources that combine to yield a flow of benefits to people."[12] In cases of depletion of natural capital, the area loses its capability to support ecosystem services that support businesses, economic activities, and other human activities. ENCORE indicates areas where investors should be concerned with market, credit, and operational risks associated with natural capital loss and areas for potential positive outcomes of investments through transitioning into nature-positive activities (UNEP-WCMC, 2021).

Using the ENCORE database, a report on nature-related financial risks in Malaysia by the World Bank and Bank Negara Malaysia (2022) introduces a spatial analysis of the country's KBAs. The report examined Malaysian banks' exposure to sectors and regions considered highly vulnerable to nature-related risks. Complementing Bank Negara Malaysia's (BNM) efforts to build capacity in assessing local financial system dependencies and impact on nature, the report

[12] UNEP-WCMC. (2021). *Mapping global hotspots of natural depletion: Using ENCORE to identify natural capital risks and opportunities and focus investor engagement.* Cambridge, United Kingdom.

examined three main types of banking exposures: (A) sectors highly dependent on ecosystem services and pose physical risk, (B) sectors that negatively affect ecosystem services and pose transition risk, and (C) KBAs that may become protected in the future. The report found that Malaysian banks are exposed to a wide array of nature-related physical and transition risks: (A) in terms of physical risk, heterogeneity in bank portfolio to one or more sectors which are highly or very highly dependent on ecosystem services (5 percent to 83 percent of total commercial loan portfolio); (B) limited exposure of banks to KBAs that may be increasingly protected going forward; (C) using an exploratory set of nature-related events, a wide range of adverse physical and transition risks scenarios; and (D) AFF and tourism are affected by several financial and transition risk scenarios.

A roadmap from the World Wildlife Fund (WWF, 2022) declared that monetary policy authorities, financial regulators, and supervisors must take immediate action on climate change and biodiversity risks since these challenges fall within the respective mandates of said authorities. The said roadmap features a "There Is No Alternative" (TINA) agenda, which outlines the measures that monetary authorities and financial regulators should implement in 2022 or 2023 at the latest.[13] Among these measures included in the TINA agenda are (A) focusing on the contributions to the rapid reduction of GHG emissions and stopping biodiversity loss and (B) adapting an appropriate time horizon in financial regulation and prudential supervision. Accompanying the roadmap is a Technical Background Report that features an in-depth analysis of the role of central banks and financial regulators in addressing climate change and biodiversity losses, the roadmap's theoretical background, and a list of prescribed measures to be implemented by said authorities. The roadmap provides three key takeaways for central banks and financial supervisors: (A) treat biodiversity loss and climate change as a single twin crisis and recognize the destabilizing effects on financial and price stability; (B) using a precautionary approach, work proactively and decisively to prevent future risks since this is within the scope of the mandates of central banks and financial supervisors; and (C) said authorities should act immediately and use all regulatory and supervisory tools available to significantly reduce GHG emissions and recover or restore biodiversity in their respective jurisdictions.

In February 2023, the Toronto Centre released a Toolkit designed for financial supervisors in emerging markets and developing economies who are considering how best to respond to climate and biodiversity-related risks or who have made progress in this area but want to check that they have covered the right topics and are headed in the right direction. The main objective of this Toolkit is to build supervisory capacity in factoring climate and biodiversity-related risks into (A) the assessment of the risks facing financial institutions and of financial stability more generally; (B) the assessment of areas where consumer or investor protection may be needed, including through standards

[13] World Wildlife Fund. (2022). *Central Banking and Financial Supervision Roadmap: Transitioning to a Net Zero and Nature Positive Economy*.

of disclosure to enable investors and consumers to make well-informed decisions; and (C) addressing the impact of climate change and biodiversity loss on financial inclusion.

The Toolkit argues that work on climate-related risks to the financial sector is generally more advanced than on biodiversity-related risks, including in terms of disclosures, metrics, definitions, and analytical approaches. However, biodiversity-related risks to financial institutions, financial stability, consumers and investors, and financial inclusion may be more important than climate-related risks for some countries and financial institutions. Climate and biodiversity-related risks may also interact as more or less equal partners in a harmful way.

There is a dearth of literature identifying the effects of climate change and biodiversity on the Philippine economy and financial system. Bayangos et al. (2021) used a dynamic panel generalized method of moments (GMM) with data from a regional quarterly rainfall damage index and branch-level database from supervisory reports of the Bangko Sentral ng Pilipinas (BSP). The said paper showed evidence that the financial system in the Philippines is vulnerable to natural disasters and that there are direct and indirect costs to banks that can impact banking operations and the viability of financial institutions. Other papers include a report by La Viña et al. (2011) which argued that the Philippines should include the environment and natural sectors as a foundation of the country's inclusive growth and focus on the continuous supply of ecosystem services as a form of natural capital. Ortiz and Torres (2020) discovered that agricultural products, such as bananas and pineapple, significantly impact biodiversity in the Philippines, primarily through habitat loss, agricultural land use, and land-use change (LULUC).[14] Berba and Matias (2022) studied the systematic organization of biodiversity data on plant and animal species in the Philippines. They found gaps in the documentation of biodiversity that can potentially constrain conservation and management efforts.

Using global data, this paper first determines the extent to which Philippine banks are exposed to risks resulting from the loss of natural capital, specifically biodiversity. As mentioned in the earlier section, not all risks caused by biodiversity loss to the financial system were studied. Second, the paper focused on the initial impact of biodiversity loss on bank-level outstanding credit by universal and commercial banks classified by economic sectors and Philippine regions and the resulting total effect on bank capital adequacy ratio using a stylized bank solvency stress test. Therefore, the results in this paper represent a baseline for total exposure. The choice of bank risks is based on the availability of balance sheets and biodiversity data. The interaction between disaster or extreme weather events and biodiversity loss could reveal that the banking system is susceptible to even more exposure to nature-related risks in general. However, the study has not considered the potential systemic risks created by biodiversity loss.

[14] LULUC: when forests are cleared to make land available for cultivation.

To the best of the authors' knowledge, the use of bank-level balance sheet data and global data on biodiversity depletion rate in analyzing the potential impact of biodiversity loss on the Philippine banking system is a first in the Philippines.

D. Empirical Approach

Empirical evidence shows that domestic institutions largely absorb production activities. Based on the latest Philippine Financial Social Accounting Matrix (PFSAM),[15] in 2017, about 90.4 percent of the total production was absorbed by domestic firms. Almost all outputs of electricity, gas, and water; construction; public administration and defense; financial intermediation services; and agriculture, hunting, forestry, and fishing were consumed domestically.

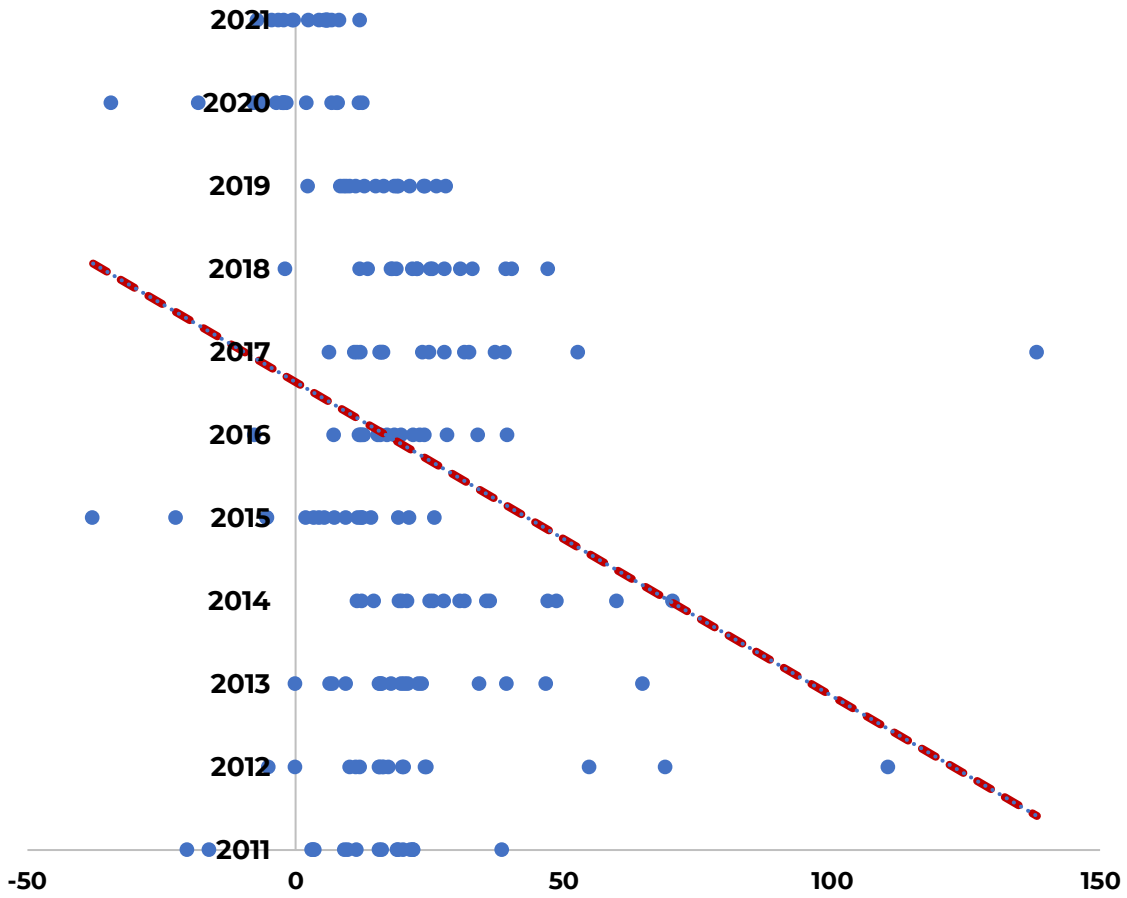
Importantly, banks mobilize deposits to provide the necessary funding for the domestic economy's requirements. Total deposits grew by 13.3 percent in September 2021 from the same period in 2020 despite the COVID-19 pandemic. The NCR had the largest share of deposit liabilities at ₱10.6 trillion (65.7 percent of the total), followed by CALABARZON (7.2 percent), Central Luzon (5.4 percent), and Central Visayas (5.0 percent). All regions registered growth rates, led by SOCCSKSARGEN (24.9 percent), Ilocos Region (13.6 percent), and Caraga (13.2 percent). Credit allocation, meanwhile, remained prudent as loans-to-deposits ratio (LDR) eased further to 62.6 percent as of September 2021 from 67.5 percent during the same period in 2020. Most regions (10 out of 17) registered a higher LDR, led by Davao Region (4.4 percentage points or ppts), Bicol Region (4.0 ppts), and CALABARZON (3.6 ppts). On the other hand, the regions which recorded the most significant drop in LDR as of September 2021 were NCR and Caraga (-8.0 ppts each), Central Visayas (-3.1 ppts), and SOCCSKSARGEN (-2.6 ppts). Despite the decline in LDR in the NCR, it is the only region with a higher LDR than the national rate at 80.4 percent. This continued to reflect the strong concentration of credit activity in the country's economic center. Other regions with high LDRs were Davao Region (43.2 percent) and SOCCSKSARGEN (39.5 percent).

In turn, outstanding loans of the banking system relative to annualized nominal GDP (net of amortization) expanded from 53.5 percent in 2017 to 56.2 percent in 2019 and to 58.7 percent in 2021. The rise in the share of the banking system's outstanding loans to annualized nominal GDP has been driven by the increase in the loans of universal and commercial banks (UKBs) —net of reverse repurchase agreements—from 43.5 percent in 2017 to 47.4 percent in 2019 and further to 49.5 percent in 2021 following the increase in loans granted to the manufacturing, wholesale, and retail trade; and real estate subsectors.

[15] The PFSAM 2017 provides an overview of the real and financial transactions in the economy. The main objective of PFSAM is to connect the multi-industrial relationships in production to the multisectoral distribution of income, consumption, investment in produced and non-produced assets and financial instruments, and the interlinkages between domestic institutions and, in turn, these institutions with the rest of the world (ROW).

In terms of year-on-year (YoY) growth, loans outstanding of UKBs decelerated from 19.4 percent in 2017 to 10.9 percent to 4.8 percent in 2021. Specific declines in growth were noted in 2011, 2013, 2015, 2018, and 2020 (Fig. 3). However, recovery has been reported in the first six months of 2022 after an increase to 12 percent. Nevertheless, the relationship between the YoY real GDP and UKBs' loans outstanding, net of amortization, has been relatively stable based on the significant bilateral Granger causality between the two indicators from March 2014 to June 2022. Moreover, the YoY growth of UKB loans outstanding has been significant in driving real GDP growth as banks provided the financial backbone needed to spur economic growth through business creation and expansion (Dayag, 2019). This means that loans outstanding by regions could be used in analyzing any potential impacts of sources of financial risks.

Figure 3. Outstanding Loans of Universal and Commercial Banks By Region, 2011-2021 (year-on-year growth, in percent)



Source: Authors

A bank solvency stress-testing exercise using bank-level loans by economic activity and by region. This study used the BSP framework for stress-testing exercises of banks. In March 2011, the BSP, through Monetary Board Resolution No. 17, dated 31 March 2011, approved semestral stress tests on banks as part of the BSP's emphasis on proactive financial surveillance and supervision. The BSP bank stress-testing exercise has three components: credit risk stress testing, uniform stress testing,[16] and real estate.[17] In this paper, we used the credit risk stress test. The credit risk stress test simulates the stress in credit quality after imposing a 20-percent[18] and a 50-percent write-off (i.e., the default rates with zero recovery) on the net carrying amount of loans and investments categorized according to the 21 economic activities based on the 2009 Philippine Standard Industrial Classification (PSIC).[19]

A contribution of this paper is the use of U/KB-level loans outstanding classified by all regions in the Philippines. Individual banks are tested to withstand impairment assuming the 20 percent and 50 percent write-off rates against the Capital Adequacy Ratio (CAR) baseline values. Interbank loans, loans to BSP, and loans and receivables arising from repurchase agreements are excluded from the credit stress tests since these are deemed loans primarily for liquidity purposes. It should be noted that overlaps exist in the assumptions used under the framework. The classification by economic activity includes the sample bank's largest credit exposures to the top 20 identified conglomerates. In addition, consumer loans to finance residential real estate also fall under loans to the real estate economic activity.

In the absence of more concrete information on biodiversity depletion rates in the Philippines, the authors first used the biodiversity depletion rate for the Philippines in the UNEP-WCMC Report (2021) and the share of each region's loans outstanding for the Philippines. The information in Table 4 was extended, and the three scenarios representing the assumed impact on banks' outstanding loans by the Philippine region were further identified. The assumed decline in outstanding loans by 10 percent, 15 percent, and 20 percent are based on specific declines in outstanding bank loans reported in the previous section: 2011 (-4.9 percent), 2013 (-4.9 percent), 2015 (-22.3 percent, -37.8 percent), 2018 (-1.9 percent), and 2020 or the COVID-19 pandemic year (-1.9 percent, -18 percent,

[16] The uniform stress-testing methodology for market risk covers the two main sources of market risk—interest rates and foreign exchange (FX) rates—based on simplified assumptions that broadly capture the inherent risk emanating from adverse movements of these factors on the trading book, the banking book, and the banks' net open FX position.

[17] Circular 839 dated 27 June 2014 introduced a prudential real estate stress (REST) limit for universal/commercial (U/KBs) and thrift banks (TBs) as a preemptive policy measure to ensure the banking system's continuous healthy exposure to the real estate sector. The REST limit shall be applied to universal, commercial, and thrift banks on both solo and consolidated bases. An assumed write-off rate of 25 percent shall be applied on a bank's real estate exposures and other real estate property.

[18] Based on the highest recorded non-performing loan ratio of 17.6 percent following the Asian financial crisis (March/June 2012).

[19] Memorandum No. M-2014-009 dated 7 March 2014 changed the basis of classification of loans, from 17 economic activities in the 1994 Philippine Standard Industrial Classification (PSIC) to 21 economic activities on the 2009 PSIC currently being used.

-34.3 percent) (Fig. 3). Table 4 shows the weighted assumed impact of various assumptions on depletion rates on bank-level loans outstanding.

Table 4. Regions with Hotspot, High, and Medium Probability of Biodiversity Depletion and Assumed Impact on Outstanding Loans of Universal/Commercial Banks[1]

No.	Region	Region name	Share of outstanding loans to total loans (percent)	Scenario 1: medium depletion rate (10 percent)	Scenario 2: high depletion rate (15 percent)	Scenario 3: hotspot (20 percent)	Total impact (percent)
1	NCR	National Capital Region	86.9			17.4	17.4
2	CAR	Cordillera Administrative Region	0.2		0.0		0.0
3	I	Ilocos	0.5		0.0	0.01	0.01
4	II	Cagayan Valley	0.5	0.0		0.01	0.01
5	III	Central Luzon	2.0		0.0	0.01	0.01
6	IV-A	CALABARZON	1.9	0.0	0.00		0.0
7	IV-B	MIMAROPA	0.3	0.0	0.0		0.0
8	V	Bicol Region	0.4	0.0			0.0
9	VI	Western Visayas	1.0	0.0	0.0		0.0
10	VII	Central Visayas	3.0	0.0	0.01	0.01	0.2
11	VIII	Eastern Visayas	0.4	0.0		0.01	0.01
12	IX	Zamboanga Peninsula	0.2	0.0	0.0		0.0
13	X	Northern Mindanao	0.6	0.0	0.00	0.0	0.0
14	XI	Davao Region	1.3	0.0	0.0		0.0
15	XII	SOCCKSARGEN	0.8	0.0	0.0		0.0
16	XIII	CARAGA	0.2		0.0		0.0
17	BARMM	Bangsamoro Autonomous Region in Muslim Mindanao	0.02		0.0		0.0

[1/] *The impact is a weighted one, based on the share of each region's loans outstanding and assumed depletion rates.*
Sources: ENCORE; Authors

Scenario 1 represents the medium probability of depletion rate and assumes a decline of 10 percent in outstanding loans for regions with a medium probability of depletion rate. Scenario 2 represents the high probability of depletion rate and assumes a decline of 15 percent in outstanding loans from the baseline. Scenario 3 assumes a decline of 20 percent in regions considered hotspots for biodiversity depletion. The total impact assumes a higher decline in outstanding loans for banks in regions that capture a higher share of total loans and are

considered hotspots, with medium and high probabilities for biodiversity depletion. Table 4 shows that bank loans to the NCR suffer the highest impact from biodiversity depletion at 17.4 percent.

It was assumed that agriculture, hunting, fishery, and hotel and restaurants (including the ecotourism subsector) are most affected by biodiversity loss in all 17 regions. KPMG (2021) showed that industry sectors most at risk from biodiversity loss are food and agri-business, consumer and industrial manufacturing, infrastructure, energy and natural resources, financial services, asset management, and insurance. Among these sectors, food and agri-business are seen as highly natural-resource dependent. This information was used as a shock for credit risk and its impact on U/KB-level solvency. This is a first approximation of the direct impact of biodiversity. The linkages with other sectors are yet to be identified.

Different scenarios in this stress test influenced individual institutions' credit, market, and profitability risks. This, in turn, impacts banks' balance sheets and profit and losses through changes in the loan loss provisions, risk-weighted assets (RWAs), and market gain/losses. Based on actual aggregates, the U/KBs' credit RWAs averaged 87.5 from 2010 to 2021. Actual credit RWA rose from 83 in 2012 to 90 in 2018 before it dropped to 87.5 in 2021. Across scenarios, additional provisioning of 20 percent in annualized net income was assumed. The authors use the information to adjust the capital and credit RWA.

The authors take their approach as an area for future research. The methodology broadly followed the International Monetary Fund (IMF) standard method for climate stress tests. While the IMF usually uses a macro-approach to translate climate scenarios into economic shocks, which are then linked to the financial sector with financial risk and banking stress-testing models, the authors followed a bottom-up approach: They focused on the biodiversity depletion rate and its impact on bank solvency using regional loans outstanding. In many studies, a bank's solvency refers to its ability to pay its debts over all horizons (short, medium, and long term). It implies that the amount of the bank's assets exceeds the amount of its liabilities, i.e., its capital is positive or exceeds a minimum threshold. A good approach to see the strength of a bank's solvency is through a stress test. The solvency stress test assesses whether banks have adequate capital buffers to withstand nature-related shocks envisioned under one year. The typical stress-testing exercise includes a three- or four-year horizon. The test only considered a year of impact analysis. The different years that were later presented are not interconnected over time, and each year is treated as a static balance sheet approach independently.

Importantly, this approach does not account for regulatory relief/forbearance and borrower-support measures adopted during the COVID-19 pandemic. The different scenarios influence individual banks' credit, market, and profitability risks. This, in turn, impacts banks' balance sheets and profit and losses through changes in the loan loss provisions, RWAs, and market gain/losses. Post-stress capital is calculated by adjusting the initial capital (C_0) of each bank and the

U/KB industry with the stressed income (I_s) and the stressed RWA (RWA_s), as follows:

$$CRs = \frac{C0+Is}{RWAs} \quad . \qquad (1)$$

The stress test depends on estimating two major accounts: the RWAs and the capital requirements for RWAs. An RWA refers to an asset classification system used to determine the minimum capital banks should keep as a reserve to reduce the risk of insolvency. Banks face the risk of loan borrowers defaulting or investments flatlining and maintaining a minimum amount of capital helps to mitigate the risks. The different classes of assets held by banks carry different risk weights and adjusting the assets by their level of risk allows banks to discount lower-risk assets.

The approach assumes the following:

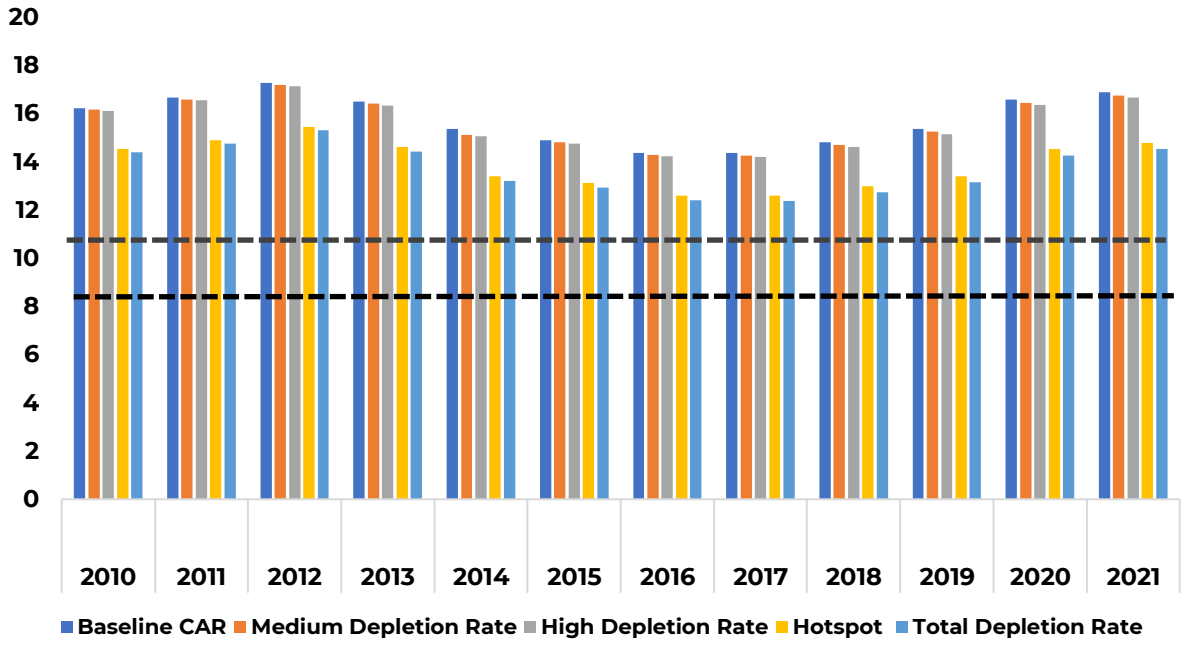
The initial bank capital and the resulting CAR for the industry are taken on a solo basis, data on annualized bank profit and loss compiled from the semestral BSP Report of the Philippine Financial System, and balance sheet data from the Financial Reporting Package. Moreover, capital requirements refer to the minimum capital that banks are required to hold depending on the level of risk of the assets they hold. The minimum capital requirements set by regulatory agencies such as the Bank for International Settlements (BIS) are designed to ensure that banks hold enough capital proportionate to the level of risk of the assets they hold. Bank capital acts as a cushion of cash if the bank incurs operational losses during its operations. In the absence of more detailed data on qualifying capital, such as the Tier 1 ratio and CET 1 ratio, solo CAR was used in the methodology.

When calculating the RWAs of a bank, the assets are first categorized into different classes based on the level of risk and the potential of incurring a loss. The banks' loan portfolio, along with other assets such as cash and investments, is measured to determine the bank's overall level of risk. The Basel Committee prefers this method because it includes off-balance sheet risks. It also makes it easy to compare banks from different countries worldwide. Riskier assets, such as unsecured loans, carry a higher risk of default and are therefore assigned a higher risk weight than assets such as cash and Treasury bills. The higher the amount of risk an asset possesses, the higher the capital adequacy ratio and capital requirements. On the other hand, Treasury bills are secured by the ability of the national government to generate revenues and are subject to much lower capital requirements than unsecured loans. The paper only focused on the movements of the share of credit risk to total RWAs. The bank-level share of credit risk to total RWAs is then derived from the CAR. The average annual credit risk weight from 2010 to 2021 for the U/KB industry is 87.5 percent.

E. Results

Using equation (1) in the previous section, the results are certainly sensitive to assumptions. In this initial study, the authors conducted a solvency stress-test exercise across the U/KBs' balance sheets from end-December 2010 to end-December 2021 using a fixed assumption on biodiversity depletion rate. Gross exposures in bank balance sheets, such as loans and debt securities holdings, are actual. The stressed CAR was compared with the 10.0 percent BSP and 8.0 percent BIS thresholds to see the resilience of banks in withstanding various scenarios of assumed depletion rates.

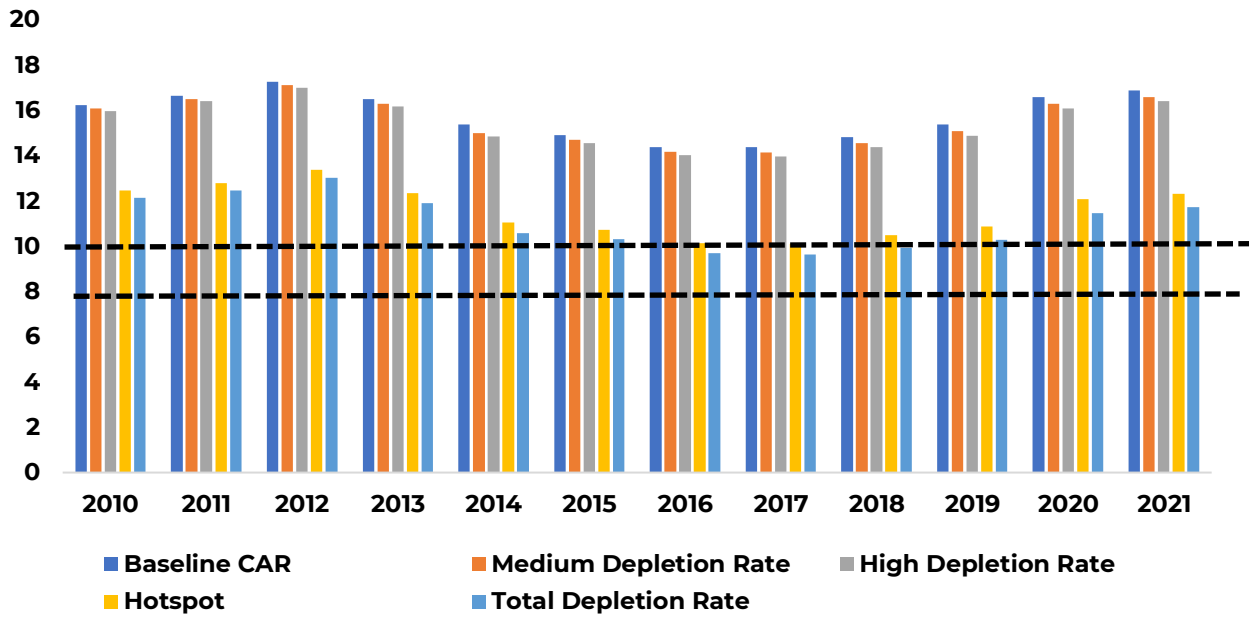
Figure 4. Equation 1: Bank Solvency Test Results, Without Income (end-December, 2010-2021, in percent)



Source: Authors

Results show that without any adjustments in bank income, a higher probability of depletion would not cause extreme bank solvency risk on its own as banks continue to post CARs above the BSP and BIS thresholds across scenarios (Fig. 4). In addition to the impact of tail events, such as a COVID-19 pandemic or extreme weather events, biodiversity depletion would reduce bank capital ratio by less than one percentage point across scenarios.

Figure 5. Equation 1: Bank Solvency Test Results, With Income (end-December, 2010-2021, in percent)



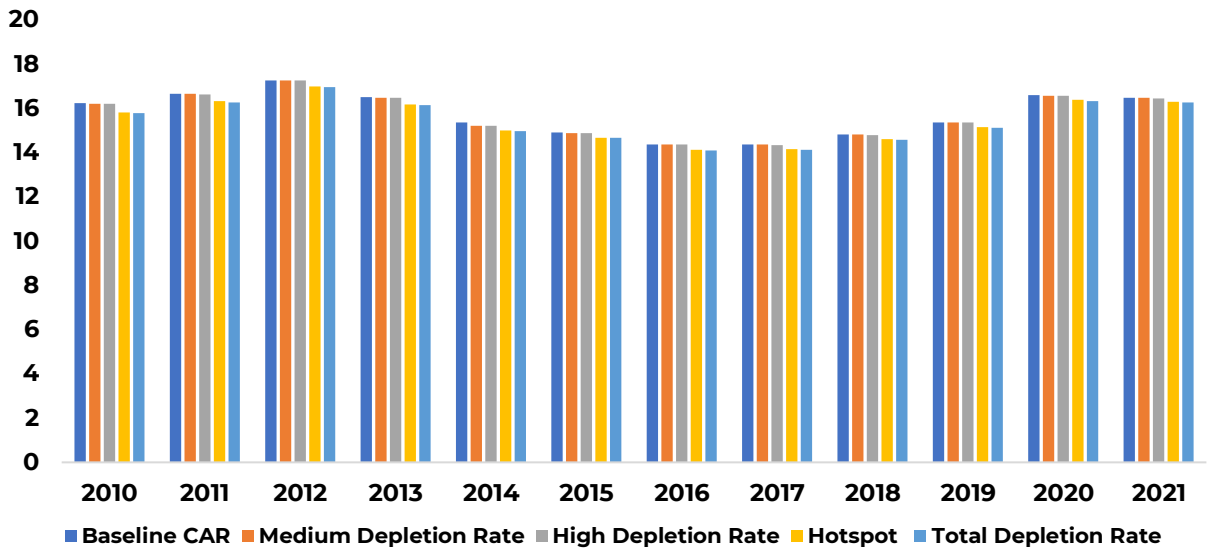
Source: Authors

With the inclusion of the impact on bank income, the effects of biodiversity loss remain marginal for those regions assumed to have medium to high biodiversity. The impact deepens for banks with loan exposures to regions classified as hotspots, such as the NCR. Bank CAR slid by 4.6 percentage points from the baseline CAR in December 2021 (Fig. 5).

Using the weighted loans outstanding by economic activity (or the share of loans by economic activity to total loans outstanding) in Fig. 6, the total impact on CAR remains modest at an average of 0.3 percentage point from 2010 to 2021. It should be highlighted that rural and cooperative banks (R/CBs), particularly active in hotspot areas, might be at risk. Bayangos et al. (2021) found evidence of deterioration in loan growth and loan quality following extreme rainfall events from 2014 to 2018 in branches of U/KBs and R/CBs in hotspot areas. Specifically, total outstanding bank loans declined by 12.5 percent on average from 2010-2021, compared to actual data, if the effects of biodiversity loss are considered.

It should be emphasized that the current focus of this initial study is on direct impacts, not including supply and value chain or indirect impacts. Considering that almost 70 percent of lending goes to the NCR, it is reasonable to assume that such indirect effects could also emerge and be material. By economic activity, the AFF sector provides the largest amount of intermediate goods and services to the economy, as mentioned in the previous section. The AFF sector is connected to almost all industries, either directly or indirectly. Thus, other sectors of the economy have a high dependency on the AFF. This also means that the indirect impacts could be larger than the direct ones.

Figure 6. Equation 1: Bank Solvency Test Results, With Income (end-December, 2010-2021, in percent)



Source: Authors

F. Conclusion

This paper first identified the extent to which Philippine banks are potentially exposed to physical risks from biodiversity loss using bank-level data of U/KBs and global data on biodiversity loss from 2010 to 2021. The possible impact of biodiversity loss on bank solvency was also explored. Currently, there are limited methodologies for assessing the economic impacts of nature and biodiversity loss. Likewise, scenarios for stress testing exercises are currently missing. This is what the NGFS Nature Task Force currently tries to address. However, not all the risks caused by biodiversity loss were analyzed due to limitations in data. Hence, the paper only focused on the initial impact of biodiversity loss on bank-level outstanding credit, the ensuing credit risk, and the total effect on bank capital adequacy ratio through a stylized bank solvency stress test. Other potential risk channels, such as market risk, are not considered. Nevertheless, the stress test results show that the initial impact of biodiversity loss on the banking system remains modest.

The initial results of the paper bring to a discussion the key role of governments in creating a conducive ecosystem for business and the financial sectors, such as in setting conditions and incentives that encourage private investment in nature-positive projects, including projects for the conservation of biodiversity. The results also bring implications for estimating the impact of biodiversity loss and nature-related risks on the banking system. Some studies observed that biodiversity loss, like climate change, is an external driver of financial risk, posing physical, reputational, and financial risks to the financial sector. In recent years, few central banks have embarked on assessing the exposures of financial

institutions. Given these exposures, financial institutions have a duty to carry out risk assessments of their portfolios and request disclosure from the clients they invest in.

One of the main characteristics of climate and nature risk in the literature is that the future might not resemble the past; hence, working with historical observations might not fully grasp the potential impact of those risks. Economic agents understand a system's structure and the nature of uncertainty sufficiently well to put probability over potential outcomes and then formulate optimal policies to maximize expected utility (so-called predict-then-act framework). Modern macroeconomic models with general equilibrium structures and rational expectations are based on such premises to formulate optimal monetary or fiscal policies. However, climate scientists face a type of uncertainty so "deep" that agents cannot even estimate or assign probabilities over potential outcomes (IMF, 2022).

Historically, an alternative to the predict-then-act framework to cope with tail risks and greater uncertainty has been scenarios, i.e., stress tests. Scenario analysis sheds light on tail events with very low probability but extremely high impact. Since their likelihood is low, these events may not affect optimal policy choices under the predict-then-act framework. Nevertheless, the framework shares first approximations of the likely impact on variables of interest.

More recently, nature-related policy discussions emphasized the importance of good decision-making under deep uncertainty. However, deep uncertainty with climate change means we should be cautious when drawing policy conclusions from stress-test results.

At this stage, more exploratory work to examine the potential impact of biodiversity loss and broader natural capital depletion on financial stability would need more focus and analysis. As for physical risk, inter-agency collaboration—including nongovernment agencies and academic or research institutions that study dependencies and exposures by economic agents, e.g., the PSA, DENR, Bankers Association of the Philippines, Chamber of Thrift Banks, Rural Bankers Association of the Philippines, and WWF-Philippines—is critical. The issue of deep model and scenario uncertainty would need to consider various models and scenarios, including the interaction between climate change risks, the intensity, and frequency of extreme weather events, biodiversity, natural capital depletion, and their combined impact on financial stability.

Improving data is also essential to increase confidence in stress-test results. As for banking sector data, increasing the granularity of the exposure data by industry and location will be good. Improving the loan-to-value (LTV) ratio collection will help assess risks from real estate loans and other relevant sectors, whether or not LTV is used as a prudential tool. Further strengthening the disclosure requirements could also help identify firms' and financial institutions' exposures to biodiversity loss and other nature-related risks. Such information

would help identify more micro-level channels of the linkages between biodiversity and natural capital and financial stability.

On the regulatory side and following Van Toor et al. (2020), supervisory authorities ensure that financial institutions report on their biodiversity risks and resilience. In December 2022, the BSP launched the *11-Point Strategy for Sustainable Central Banking* (SCB) to promote sustainability principles and practices in its policies, operations, and financial system. Under the SCB, the BSP, through the Taskforce on Nature-related Financial Disclosures, is expected to undertake exploratory work on risk management and disclosure frameworks for banks to report and act on nature-related risks. Meanwhile, the BSP, the Securities and Exchange Commission, and the Insurance Commission, under the auspices of the Financial Sector Forum, are currently developing the local sustainable finance taxonomy. The taxonomy could also be eventually enhanced to include nature-related aspects.

References

ASEAN Center for Biodiversity. (2017). *ASEAN Biodiversity Outlook 2*. ASEAN Center for Biodiversity.

Ambal, R., Duya, M., Cruz, M., Coroza, O., Vergara, S., De Silva, N., Molinyawe, N., & Tabaranza, B. (2012). Key biodiversity areas in the Philippines: Priorities for conservation. *Journal of Threatened Taxa 4*(8), 2788-2796.

Ani, P. A. & Castillo, M. (2020). *Revisiting the state of Philippine biodiversity and the legislation on access and benefit sharing*. Food and Fertilizer Technology Center for the Asian and Pacific Region Agricultural Policy Platform. https://ap.fftc.org.tw/article/1836

Aquino-Gayao, G. (2014). The Biodiversity Finance Initiatives Philippines, Policy and institutional review final report, November.

Augeraud-Veron, E., Fabbri, G., & Schubert, K. (2017). *The value of biodiversity as an insurance device*. Aix-Marseille School of Economics Working Papers No. 2017-9.

Bank de France. (2021). *Biodiversity loss and financial stability: a new frontier for central banks and financial supervisors?* Financial stability and financial system. Bulletin de la Banque de France No. 237/7. September-October 2021.

Bartram, S., Hou, K., & Kim, S. (2022). *Real effects of climate policy: Financial constraints and spillovers*. .

Bayangos, V., Cachuela, R., & Del Prado, F. (2021). Impact of extreme weather episodes on the Philippine banking sector – Evidence using branch-level supervisory data. *Latin America Journal of Central Banking* (2021) 100023.

Bangko Sentral ng Pilipinas. (2017). *Philippine Financial Social Accounting Matrix*. Department of Economic Research and Department of Economic Statistics. Monetary and Economics Sector.

Berba, C. & Matias, A. (2022). State of biodiversity documentation in the Philippines: Metadata gaps, taxonomic biases, and spatial biases in the DNA barcode data of animal and plant taxa in the context of species occurrence data. *PeerJ* 10:e13146 DOI 10.7717/peerj.13146.

Biodiversity Management Bureau. (2015). *Philippine Biodiversity Strategy and Action Plan, 2015-2028. Bringing Resilience to Filipino Communities*. Department of Environment and Natural Resource.

Calice, P., Diaz Kalan, F., & Miguel, F. (2021). Nature-Related Financial Risks in Brazil. World Bank Policy Research Working Paper 9759.

Cevik, S. & Jalles, J. (2022). *For Whom the Bell Tolls: Climate Change and Income Inequality*. International Monetary Fund Working Paper WP/22/103.

Cevik, S. & Miryugin, F. (2022). *Rough Waves: Climate Change and Firm Performance*. International Monetary Fund Working Paper WP/22/102.

Chenet, H., Kedward, K., Ryan-Collins, J., & van Lerven, F. (2022). *Developing a precautionary approach to financial policy – from climate to biodiversity*. The Inspire Sustainable Central Banking Toolbox Policy Briefing Paper 02. April 2022.

Congressional Research Service. (2021). *In Focus*. United States Government Reports: 8 July 2021.

Dasgupta, P. (2021). *The Economics of Biodiversity: The Dasgupta Review*. London: HM Treasury.

Dayag, A. (2019). Growth of Universal Banking in the Philippines: A Correlational Study with Economic Growth. *International Journal of Finance & Banking Studies* (2147–4486) 8(3):66–76. August 2019.

Department of Environment and Natural Resources (DENR). (2019). *Updated national list of threatened Philippine fauna and their categories*. DENR Administrative Order No. 2019-09. Accessed from dao-2019-09.pdf (bmb.gov.ph)

Department of Environment and Natural Resources (DENR). (2017). *Updated national list of threatened Philippine plants and their categories*. DENR Administrative Order No. 2017-11.

Deloitte. (2022). *Global Impact Report: Building Better Futures*. Deloitte Global.

Department of Environment and Natural Resources - Biodiversity Management Bureau. (2016). *Philippine biodiversity strategy and action plan 2015–2028 Bringing resilience to Filipino communities*.

Department of Environment and Natural Resources - Biodiversity Management Bureau. (2014). *The Fifth National Report to the Convention on Biological Diversity*.

Department of Environment and Natural Resources - Forest Management Bureau. (2012). *Philippine Forestry Statistics 2012*. Quezon City, Philippines.

Dunz & Power. (2021). *Climate-Related Risks for Ministries of Finance – An Overview*. Washington, DC: Coalition of Finance Ministries for Climate Action.

Food and Agriculture Organization of the United Nations. (1999). Agricultural Biodiversity, Multifunctional Character of Agriculture and Land Conference. Background Paper 1. Maastricht, Netherlands. September 1999.

Francia, M. (2020). *Environmental degradation and the financial system*. Opening remarks, First Conference on Biodiversity and Environmental Challenges for the Financial System. 20 November 2020.

Hansen, L. (2022). Central banking challenges posed by uncertain climate change and natural disasters. *Journal of Monetary Economics*, No. 125, pp. 1-15.

Intergovernmental Panel on Climate Change. (2022). *Climate Change 2022: Impacts, Adaptation, and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). (2019). *The global assessment report on biodiversity and ecosystem services: Summary for Policymakers.* Bonn, Germany: IPBES.

International Monetary Fund (IMF). (2022). *The Philippines Financial Sector Assessment Program Technical Note: Bank Stress Test for Climate Change Risks.* Prepared by Monetary and Capital Markets Department, Internartional Monetary Fund, Washington DC, USA.

KPMG. (2021). *Demystifying Natural Capital and Biodiversity*. December 2021.

La Viña, A., Kho, J., Celeda, M., Regunay, J., Perez, T., & Ang, L. (2011). *Philippine Biodiversity and Tropical Forestry Analysis: Conserving Tropical Forests and Biodiversity for Human Development and Inclusive Growth*. 2011 Foreign Assistance Act (FAA) 118/119 Report, Ateneo School of Government for the United States Agency for International Development/Philippines.

Lim, M. (2014). *State of the Biodiversity Address*. 5 August, Miriam College, Quezon City, Philippines.

Menon, R. (2022). *Bending the Curve of Nature Loss.* Keynote Remarks by Ravi Menon, Managing Director of the Monetary Authority of Singapore and Chair of the Network for Greening the Financial System, at the United Nations Biodiversity Conference (COP15), Finance and Biodiversity Day, on 14 December 2022, Montreal, Canada.

Mercado, D. (2016). *Compilation and synthesis of valuation studies on Philippine biodiversity*. A United Nations Development Programme-Biodiversity Finance Initiative project.

Network for Greening the Financial System (NGFS). (2018). NGFS: First Progress Report. October 2018.

Network for Greening the Financial System (NGFS). (2022). *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. NGFS Occasional Paper.

Ong, P. S., Afuang, L. E., & Rosell-Ambal, R.E. (eds.). (2002). *Philippine Biodiversity Conservation Priorities: A Second Iteration of the National Biodiversity Strategy and Action Plan.* Quezon City, Philippines: Department of Environment and Natural Resources-Protected Areas and Wildlife Bureau, Conservation International Philippines, Biodiversity Conservation Program-University of the Philippines Center for Integrative and Development Studies, and Foundation for the Philippine Environment.

Ortiz, A. & Torres, J. (2020). Assessing the Impacts on Agriculture and its Trade on Philippine Biodiversity. *Land*, Vol.9, No. 403.

Painter, M. (2020). An Inconvenient Cost: The Effects of Climate Change on Municipal Bonds. Journal of Financial Economics, Vol. 135, pp. 468–482.

Pörtner, H., Scholes, R., Agard, J., Archer, E., Arneth, A., Bai, X., Barnes, D., Burrows, M., Chan, L., Cheung, W., Diamond, S., Donatti, C., Duarte, C. M., Eisenhauer, N., Foden, W., Gasalla, M., Handa, C., Hickler, T., Hoegh-Guldberg, O., Ichii, K., Jacob, U., Insarov, G., Kiessling, W., Leadley, P., Leemans, R., Levin, L., Lim, M., Maharaj, S. S., Managi, S., Marquet, P., McElwee, P., Midgley, G., Oberdorff, T., Obura, D., Osman, E. O., Pandit, R., Pascual, U., Pires, A., Popp, A., Reyes-García, V., Sankaran, M., Settele, J., Shin, Y., Sintayehu, D. W., Smith, P., Steiner, N., Strassburg, B., Sukumar, R., Trisos, C., Val, A., Wu, J., Aldrian, E., Parmesan, C., Pichs-Madruga, R., Roberts, D., Rogers, A., Díaz, S., Fischer, M., Hashimoto, S., Lavorel, S., Wu, N., & Ngo, H. (2021). *Report on biodiversity and climate change.*

Intergovernmental Science-Policy Biodiversity and Ecosystem Services-Intergovernmental Panel on Climate Change Report. June 2021.

Pörtner, H., Scholes, R.J., Arneth, A., Barnes, D.K., Burrows, M.T., Diamond, S.E., Duarte, C.M., Kiessling, W., Leadley, P., Managi, S., McElwee, P., Midgley, G., Ngo, H.T., Obura, D., Pascual, U., Sankaran, M., Shin, Y.J., and Val, A.L . (2023). Overcoming the coupled climate and biodiversity crises and their societal impacts. *SCIENCE* Vol. 380, Issue 6642 (21 Apr 2023). DOI: 10.1126/science.abl4881.

Rebugio, L., Cruz, R., Carandang, R., Tolentino, E., de la Cruz, L., Lasco, R., Visco, R., Dizon, J., Pulhin, F., Dalmacio, R., Bantayan, N., Calderon, M., & Camacho, L. (2005). *Forest restoration in the Philippines: A review of research and development initiatives*. University of the Philippines Los Baños, Office of the AKECOP Coordination in the Philippines, College of Forestry and Natural Resources, College, Laguna.

Roncoroni, A., Battiston, S., Escobar-Farfan, L., & Martinez-Jaramillo, S. (2021). Climate risk and financial stability in the network of banks and investment funds. *Journal of Financial Stability, No. 54*.

Smale, D. A., Wernberg, T., Oliver, E. C. J., Thomsen, M., Straub, S. C., Burrows, M. T., Alexander, L. V., Donat, M. G., Feng, M., Hobday, A. J., Holbrook, N. J., Perkins-Kirkpatrick, S. E., Scannell, H., Gupta, A. S., & Payne, B. (2019). Marine heatwaves threaten global biodiversity and the provision of ecosystem services. *Nature Climate Change*, pp. 9, 306–312. https://doi.org/10.1038/s41558-019-0412-1

Svartzman, R., Espagne, E., Gauthey, J., Hadji-Lazaro, P., Salin, M., Allen, T., Berger, J., Calas, J., Godin, A., & Vallier, A. (2021). *A "Silent Spring" for the Financial System? Exploring Biodiversity-Related Financial Risk in France*. Banque de France Working Paper No. 826. August 2021.

Swiss Re Institute. (2020). *Biodiversity and Ecosystem Services: A business case for re/insurance*. Swiss Reinsurance Company Ltd.

Tamayo, N. C., Anticamaraa, J., & Acosta-Michlik, L. (2018). National Estimates of Values of Philippine Reefs' Ecosystem Services. *Ecological Economics*, 146 (2018), 633–644.

Toronto Centre. (2023). *A Climate and Biodiversity Risks Toolkit for Financial Supervisors*. Updated February 2023.

United Nations Environment Programme-World Conservation Monitoring Centre. (2021). *Mapping global hotspots of natural depletion: Using ENCORE to identify natural capital risks and opportunities and focus investor engagement*. Cambridge, United Kingdom.

Van Toor, J., Piljic, D., Schellekens, G., van Oorschot, M., & Kok, M. (2020). *Indebted to nature: Exploring biodiversity risks for the Dutch financial sector.* De Nederlandsche Bank. June 2020.

World Bank. (2009). *The Philippines: Country Environmental Analysis*. Report No. 52398-PH. Sustainable Development Department East Asia and Pacific Region.

World Bank & Bank Negara Malaysia. (2022). *An Exploration of Nature-Related Financial Risk in Malaysia*. March 2022.

World Wildlife Fund. (2022). *Central Banking and Financial Supervision Roadmap: Transitioning to a Net Zero and Nature Positive Economy*.