Biodiversity-related Risks and the Financial System: Evidence from Mexico

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EXECUTIVE SUMMARY

The degradation of biodiversity and the loss of ecosystem services are critical threats to Mexico's economic and financial stability. This paper synthesizes the main results of the article "Biodiversity-related Risks and the Financial System: Evidence from Mexico" which aims to analyze, from an economic-financial approach, the link and dependence of productive sectors with essential ecosystem services such as water supply, pollination and climate regulation. The findings reveal that a high percentage of national production, employment and lending portfolio is exposed to risks associated with environmental degradation, either directly or through complex supply chains.

The analysis is based on the integration of input-output models, georeferenced data and simulation of scenarios, considering both physical risks (e.g., decrease in water availability) and transition risks (e.g., restoration and environmental conservation policies). Based on these results, strategic recommendations are proposed to incorporate environmental criteria in financial supervision, adjust regulatory frameworks and incentivize sustainable investments.

[1]"Biodiversity-related Risks and the Financial System: Evidence from Mexico" (2025). Authors: Serafín Martínez Jaramillo; Luis Onésimo Escobar; Karina Caballero; Carlos López; Saúl Basurto.

KEY MESSAGES

- Between 48 and 66% of total output, 33 and 70% of total jobs, and 28 and 53% of total loans are potentially at risk, as they show high or very high dependence on ecosystem services and environmental impacts. The loan portfolio's exposure to water-related events is transferred through the economy's supply chains, as 80% of the national loan portfolio is allocated to industries that act as net importers of water.

- In total, the analysis showed that 49% of national production, 33% of employment and 28% of the loan portfolio are linked to industries with high direct impacts. When including indirect effects, these values rise to 66%, 70% and 53%, respectively.

- The exposure of the loan portfolio to water-related events cannot be directly observed, but is transferred through the economy's supply chains, as 80% of the national loan portfolio is allocated to industries that act as net importers of incorporated water. In the face of water crises or extreme events, these effects propagate and amplify systemic risks throughout the economy.

- Agricultural and extractive production depends heavily on biotic resources; Therefore, any interruption, for example, in the supply of water, has cascading effects on production, employment and bank credit..

- Agriculture, although it has a low allocation of direct credit (2.6%), transfers its dependence through value chains such as manufacturing and services.

- More than 65% of the value added in manufacturing and services depends indirectly on natural resources.

- The industries that generate the greatest environmental pressure—mining, agriculture, heavy manufacturing, power generation, and construction—have the potential to spread financial risk throughout the economy.

CONTEXT AND BACKGROUND

Biodiversity and ecosystem services are the basis of economic activity; Without them, key activities such as agriculture, tourism, fishing and the extractive industry would be severely compromised. Mexico, renowned for its exceptional natural wealth, is experiencing accelerated environmental degradation that exposes key sectors to significant losses.

Biodiversity-related risks can originate from two sources. Physical sources of risk refer to the degree to which economic activities depend on the degradation of ecosystem services, such as the provision of water for irrigated agricultural land, pollination, or flood protection. The sources of transition risk are related to the imbalance between the optimization behavior of companies and policies that seek to achieve a nature-positive economy, such as the creation of new protected areas for conservation or the prohibition of activities with large negative impacts on nature.

Recent studies have looked at how biodiversity-related risks could impact the financial system, finding that a significant portion of banks' loan portfolios depend on at least one ecosystem service or are exposed to transition risks due to the financing of activities harmful to biodiversity. This underscores the need to generate more evidence on the potential impacts of these risks on the financial system.

Since 2015, UNDP's Biodiversity Finance Initiative (BIOFIN) in Mexico has developed an agenda that seeks to integrate biodiversity into the financial system and economic sectors that were not commonly considered as part of the factors of production.

With the support of UNDP and the collaboration of key state and financial institutions such as the Bank of Mexico, the Ministry of Finance and Public Credit, and the National Banking and Securities Commission, BIOFIN has developed innovative mechanisms to align investments, reform financial flows, and incorporate environmental, social, and governance (ESG) criteria into public development banks. This study is an additional effort to accelerate and multiply the objectives of this agenda.

METHODOLOGY AND APPROACH

To contribute to the advancement of this line of research, this document offers two main contributions. First, it combines dependency and impact ratings from ENCORE, input-output matrices, microdata obtained from economic censuses, and geographic information systems (GIS) data, using a methodological framework to analyze the extent to which physical and transition scenarios at the national level would affect the financial system. Second, it presents the first assessment of its kind for Mexico that integrates both financial and socioeconomic variables.

The study is based on a comprehensive methodology that combines economic, financial and geospatial analysis, allowing to identify precisely how the dependence of productive sectors on ecosystem services affects key indicators of the economy and finance. This approach is structured in four components:

I. Data integration

- **Sources:** Specialized databases (such as ENCORE) were used, which assign dependency and environmental impact scores, along with input-output matrices and microdata from economic censuses.

- **Classification:** Data was correlated by matching industry codes (ISIC and NAICS) to assign accurate scores to 263 industries.

- **Georeferenciation:** Spatial data from the Economic Census and the Agricultural Census were incorporated to map critical areas and evaluate the exposure of strategic sectors to environmental risks.

2. Physical and transition risk assessment

- **Physical risks:** The impact of stress events, such as water crises, was simulated using real information on water use by industry. Coefficients were calculated (e.g., HM^3 per million pesos) and a matrix was constructed that reflects the flows of water incorporated in inter-industrial transactions, demonstrating that up to 80% of the loan portfolio is indirectly exposed to water scarcity.

- **Riesgos de transición:** Se evaluaron los efectos de políticas de restauración, como las estipuladas en el Marco Mundial de Biodiversidad Kunming-Montreal, integrando datos georreferenciados con información de firmas de gran y mediano tamaño, para proyectar pérdidas en producción, empleo y créditos ante restricciones de uso de servicios ambientales en zonas críticas.

3. Input-ouput models and supply chain analysis

Simplifying the information, the input-output model explains how each sector of the economy depends on inputs provided by others. For this exercise, the economy is characterized as a large supply system, where each industry produces goods and services to meet final demand and, at the same time, depends on inputs from other industries. The methodological steps can be summarized as follows:[3]:

[2] ENCORE: Exploring Natural Capital Opportunities, Risks and Exposure. More information at: https://www.encorenature.org/en
[3] To review the detailed methodology, check section 3, **Method & Data**, of the full document.

- **Technical coefficients matrix:** A matrix (called A) is developed that reflects the direct relationships between sectors, showing the amount of inputs necessary to produce an output unit.

- **Leontief matrix**: To capture indirect effects that propagate throughout the supply chain, matrix A is transformed into the Leontief matrix. This tool calculates the total impact on the economy of a change in demand or production in a given sector.

- **D & P matrices:** In addition to the previous two additional matrices, D and P, which organize the scores of direct dependencies on ecosystem services and direct environmental pressures, respectively, for all industries in the economy.

- **Multiplication of scores:** The matrices of dependence (D) and impact (P) are multiplied by the Leontief matrix, generating:
  - Matriz Ω (Omega): Quantifies the indirect dependence of each industry on ecosystem services.
  - Matriz Φ (Phi): Reflects how environmental impacts are indirectly transmitted.

Elements of methodological innovation and use of geospatial (GIS) tools

- **Assesment and visualization:** integration of GIS tools enabled the visual representation of critical areas and risk pathways, facilitating the identification of vulnerabilities in the territory.

- **Simulations and scenarios:** heat maps were used to visualize resource flows (such as the water incorporated into the chain), and simulations were applied to projects the effects of changes in environmental policies on production, employment, and credit allocation.

- **Multidimensional application:** the combination of economic, financial, and spatial analysis provides a solid empirical basis that allows for the formulation of specific mitigation strategies and the priorization of interventions in vulnerable sectors.

- **Linkage analysis:** The "backward" (how much a sector depends on external inputs) and "forward" (the importance of one sector as a supplier to others) linkages are analyzed to identify key industries whose interconnectedness is crucial for economic and financial stability.

- **Socioeconomic linkage:** Dependency and impact ratings were linked to socioeconomic data in Mexico. The updated version of the ENCORE dataset reporting dependencies on 25 ecosystem services and impacts on 13 nature-related elements from 271 industries was used to assign dependency and pressure scores to the socioeconomic data reported for 263 industries in Mexico. Likewise, the INEGI equivalence table was used to match the ISIC codes with the NAICS codes.

- **Linkage with sectoral information:** dependency and impact ratings were assigned to the input-output matrix, as well as to other socioeconomic variables such as total output, employment, and loan portfolio. To incorporate these variables, the following were used: the System of National Accounts, the 2019 Economic Census and the 2022 Agricultural Census. These censuses not only provide information on socioeconomic variables, but also record the location of 4.8 million businesses and 4.6 million farms, which was essential for conducting spatial assessments of the potential impacts of biodiversity-related risks on the economy and financial system. Finally, the industry-specific loan portfolio was obtained from public data generated by the Bank of Mexico.

RESULTS

Economic dependencies and ecosystemic services

The evaluation considers the relationship between Mexican industries and ecosystem services. Using input-output matrices and ENCORE data, both direct and indirect dependencies of 263 industries classified under the NAICS system were identified.

The direct dependency ratings in the ENCORE database are categorical (i.e., 0, 0.2, 0.4, 0.6, 0.8, and 1), while indirect dependencies, resulting from matrix multiplication, generate a continuum. To generate the resulting tables between industries and dependencies, the following table and color code were generated.

Dependencies/Indirect Impacts											
Very high		High		Medium		Low		Very low		Minimal	
1.3	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0

Dependencies/Indirect Impacts					
Very high	High	Medium	Low	Very low	Minimal
1	0.8	0.6	0.4	0.2	0

With this color code, **figures 3 and 4** were generated to present the relationships of direct and indirect dependencies. **Figure 3** presents an economic comparison between the direct and indirect dependencies of ecosystem services. High and very high direct dependencies, present in certain industries, are transferred to other industries as indirect dependencies due to their participation in supply chains. For example, agricultural sectors show high direct dependencies on water, soil services, and climate regulation, while the food industry's direct dependencies on these services are relatively weak. However, in the heat map of indirect dependencies, the food industry increases its dependence on these services due to the high participation of agriculture in its supply chains. In addition, indirect dependencies of the industrial and manufacturing sectors are high due to the transfer of high direct dependencies through their supply chains, especially in the case of water, biomass services, genetic material, soil quality regulation and pollination for the food industry, the light wood industry, etc. petroleum derivatives and various chemical industries. Health services show a high dependence on water, while services of visual, spiritual, artistic and symbolic amenity are important for education, health and some social services, for example, tourism.

Figure 4 illustrates the direct impact of each sector on each of the environmental pressures. As can be seen, services are the sector with the lowest impact on all variables, showing low and very low impacts on disturbances (e.g., noise, light), emissions of toxic pollutants in soil and water, volume of water use, generation and release of solid waste, land use area, greenhouse gas (GHG) emissions and other air pollutants, as well as emissions of nutrients from the soil and water pollutants. In contrast, the mining and steel industries exhibit high and very high levels of impact on disturbances (e.g., noise, light) and emissions of toxic pollutants into soil and water.

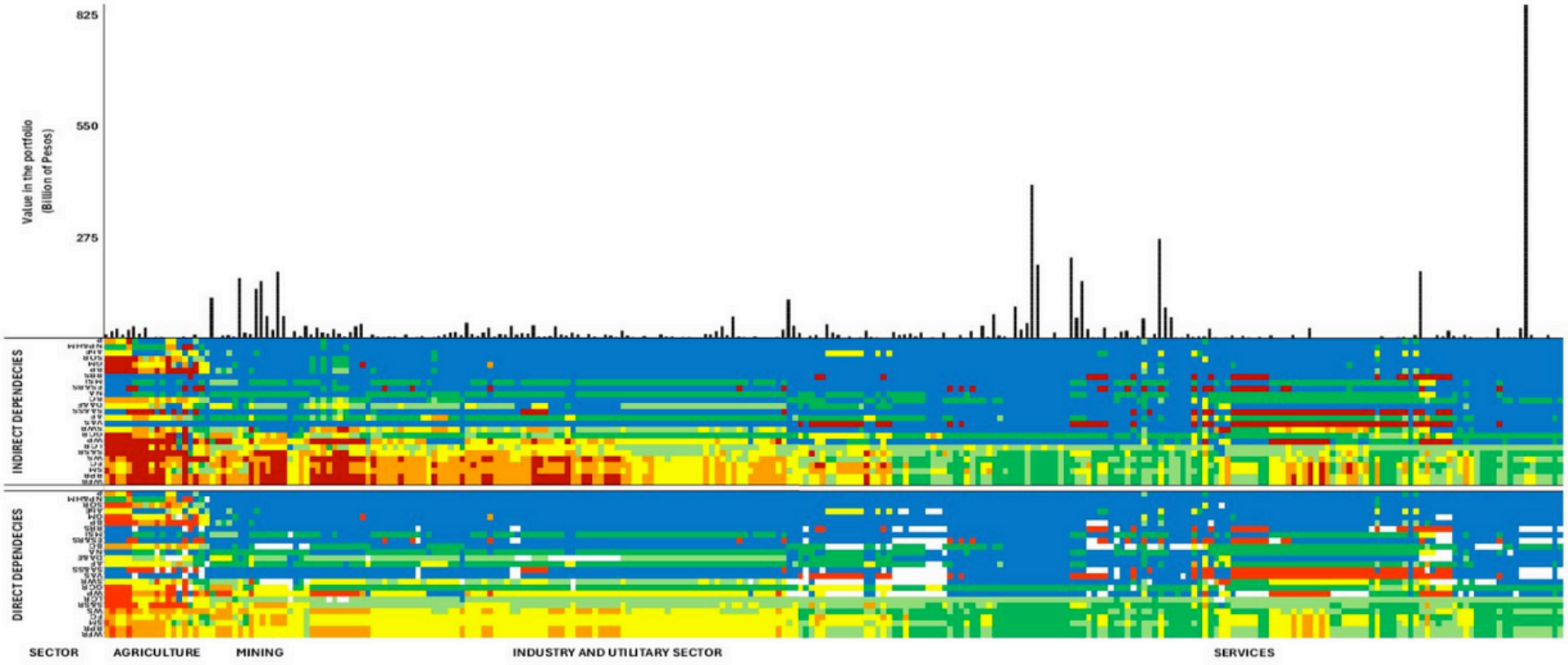

Figure 3: Direct and indirect dependencies linked to the credit portfolio.

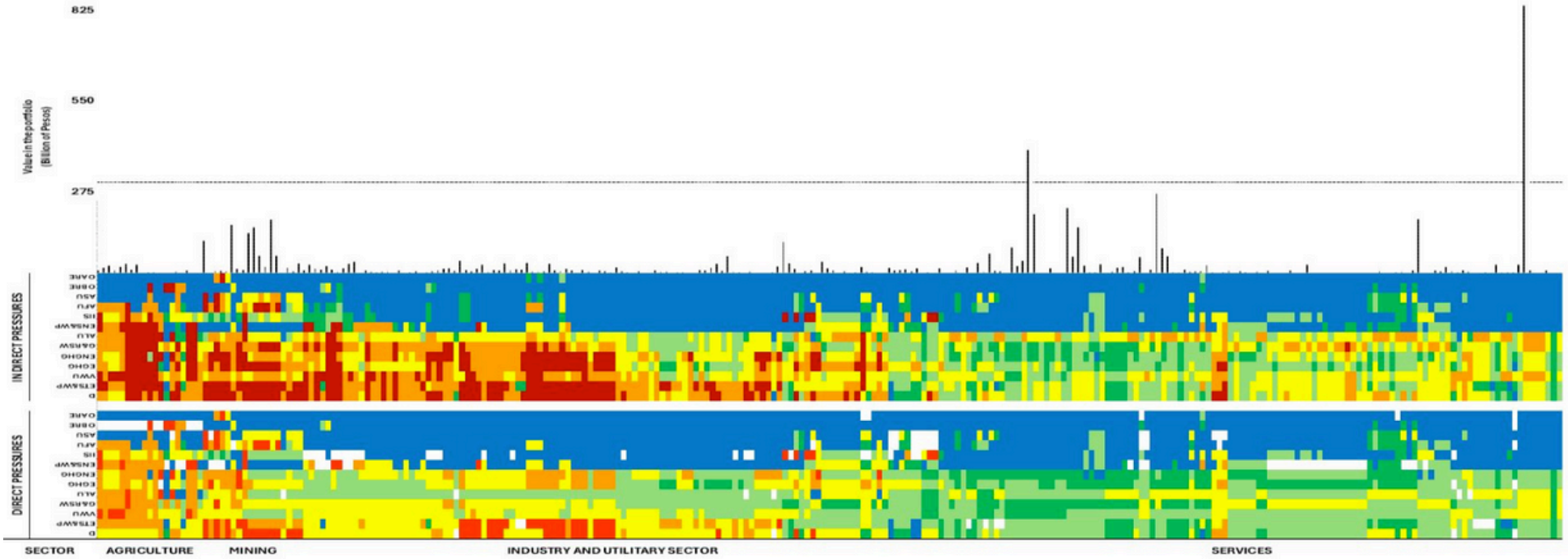

Figure 4: Direct and indirect pressures linked to the loan portfolio.

Finally, **Table 1** summarizes these results and links them to socioeconomic (production and employment) and financial (credit by sector) variables. As can be seen, a large number of industries have high or very high direct ratings in at least one ecosystem service (146), representing 47% of gross product and employment, as well as 46% of the credit portfolio of the entire economy. These figures increase when considering the cascading effects through the supply chains of each industry, as now 189 industries show high or very high indirect dependencies in at least one SE, representing 66% of gross product, 53% of employment and 52% of the credit portfolio.

Table 1: Financial exposure across the economy

	Industries with high or very high ratings	Production value (Million USD)	Jobs (millions)	Credits (Million USD)
Direct dependencies	146	1041423	27.91	133,091.00
%	55.50%	47.80%	46.90%	45.50%
Indirect dependencies	189	1,432,482.00	31.65	150,590.00
%	71.90%	65.70%	53.20%	51.50%
Direct impacts	104	1,065,516.00	19.56	83,135.00
%	39.50%	48.90%	32.90%	28.40%
Indirect impacts	171	1,436,179.00	29.22	154,293.00
%	65%	65.90%	69.60%	52.80%

Similar behavior is observed in relation to pressures on various categories of environmental impacts. In total, 104 industries have high or very high ratings in at least one of the impact categories, representing 49% of the national product, 33% of employment, and 28% of the national credit portfolio. However, when considering indirect effects along industrial supply chains, 171 industries are identified with high or very high ratings in at least one impact category, representing 66% of gross product, 70% of employment, and 53% of the credit portfolio of the entire economy.

Risk scenario simulation

Once the dependency and impact results were obtained, two risk scenarios were generated to expose how water scarcity or changes in restoration policies could modify the risk exposure of the economy.

Physical risk: water scarcity

The construction of the physical risk scenario uses national water concession data organized according to economic activities, correlated with Mexico's industrial classifications and analyzed using the input-output model. This model includes specific vectors that quantify the volume of water directly used by each industry and calculates indirect flows of water incorporated through supply chains.

Initial results indicate that agriculture dominates water consumption with 67.5% of the national total, while sectors such as manufacturing and services, although smaller direct consumers, critically depend on this resource through upstream inputs. This underscores the disconnect between the intensity of direct use of the resource and systemic financial exposure.

The analysis highlights that manufacturing (12.6% of the loan portfolio) and services (69.8%) are sectors that are net importers of water bottles, that is, their exposure to water risk is transmitted through value chains. For example, indirect dependence on the manufacturing sector is amplified by the central role that agriculture plays as a supplier of essential inputs. This finding is supported by calculations that show that 26,256 cubic hectometers of soaked water flow to manufacturing and 5,473 cubic hectometers to services, evidencing that disturbances in water availability disproportionately affect downstream sectors (industries and services). In addition, it is highlighted that, although the volumes of water involved in services are smaller, the essential characteristic of water in economic activities without substitutes makes them highly vulnerable to even small interruptions.

In terms of implications, this scenario exposes a significant financial risk, since 80% of the national loan portfolio is linked to net importing sectors of embedded water. Although agriculture has a low direct exposure in terms of credit (2.6%), interruptions in access to water can generate cascading effects through their interactions with manufacturing, processed foods, and logistics, among others. This analysis emphasizes the need to mitigate water risks not only at the direct sectoral level, but also by addressing vulnerabilities in the interconnections of value chains. The evidence supports the formulation of policies focused on water sustainability, the prioritization of key industries, and the strengthening of financial mechanisms to absorb shocks linked to this strategic resource.

Transition risk: Ecosystem restoration

The construction of the transition risk scenario is based on target 2.1 of the Kunming-Montreal Global Biodiversity Framework, which promotes the effective restoration of at least 30% of degraded terrestrial ecosystems. To this end, the Priority Restoration Areas (RPAs) were identified using data from the National Restoration Program, which cover 75.5 million hectares, equivalent to 40% of the national territory. Through a geospatial analysis, the coordinates of large and medium-sized companies with potentially harmful activity in the APRs were crossed, using data from the National Statistical Directory of Economic Units (DENUE). This procedure made it possible to identify specific companies that would be subject to restrictive regulations if restoration policies were implemented.

The analysis reveals significant economic implications, both direct and indirect, for the sectors involved. Directly, 30 companies are identified in sub-industries such as electricity generation, agricultural support activities and water systems, which would face restrictions. These bans would affect approximately $1.1 billion in production, along with 4,480 jobs and $290.6 million in credits. In indirect terms, the impact extends to 479 companies in 378 industries, with losses estimated at $8.8 billion USD of production, $702 million USD of credits and 65,471 jobs. This finding underscores the systemic interconnectedness between sectors and the spread of financial risks along supply chains.

Results highlight significant variations in risk exposure between sectors. For example, mining shows a high level of vulnerability, with up to 32.9% of its loan portfolio potentially affected, while industries such as the manufacture of sugar products faces an exposure of 15.51%. These results highlight the need to adopt comprehensive approaches that balance conservation objectives with economic stability, prioritizing strategic sectors and developing financial mechanisms that mitigate transition impacts.

Important note from BIOFIN: This transition risk was developed from the perspective of risk exposure across economic sectors. It does not consider the economic, financial, social, and environmental co-benefits of the restoration program, which may equal or exceed the associated costs. This issue is not discussed in this document, and the valuation of these benefits must be verified in the development of public policies.

IMPLICATIONS FOR THE FINANCIAL SYSTEM

Accumulating evidence shows that biodiversity degradation is not only an ecological problem; it also represents a significant financial risk. The negative effects of degradation ripple along supply chains, extending vulnerability to sectors that, while they may not be directly dependent on ecosystem services, are indirectly impacted.

For the financial sector, this means:

- **Integration of Environmental Criteria in Financial Supervision:** Include metrics that quantify industries' dependence on ecosystem services and evaluate their environmental impacts, both direct and indirect, aligning them with international standards (TNFD, GRI, ISSB). This will allow risk assessments to recognize and quantify exposure to critical ecological factors.

- **Development of Green Financing Mechanisms:** Promote innovative financial instruments, such as:
  - **Biodiversity mitigation and compensation mechanisms:** To channel investments towards the recovery of degraded ecosystems. These include projects like ecological or green infrastructure, biodiversity credits and bonds, insurance, and risk instruments associated with sustainable practices, among others.
  - **Subsidies and preferential rates:** Grant and financing instruments that modify the behavior of economic agents through incentives, prices, and preferential terms.

- **Implementation of ecological resistance tests:** Design specific scenarios (e.g., prolonged droughts or expansion of protected areas) to assess the capacity of the financial system in the face of environmental shocks. These tests, which cover direct and indirect effects throughout the production chain, will make it possible to anticipate and mitigate risk concentrations.

- **Strengthening cross-sectoral governance:** Promote collaboration between banks, regulators (such as BANXICO, SHCP and CNBV) and environmental organizations through inter-institutional working groups. The exchange of compatible and georeferenced data will facilitate decision-making based on local evidence and rapid response to changes in the environment.

- **Information quality and articulation improvement:** Harmonize industrial classifications (e.g. between ISIC and NAICS) and deepen regional analyses, facilitating the identification of critical areas and sectors. This effort will allow for continuous monitoring and accurate updating of the risks associated with biodiversity loss.

- **Geolocation of financing improvement:** Improve credit allocation systems so that the financial sector knows the final destination of the financing. This will allow you to better understand the exposure to physical and transition risks of your credit portfolio.

CONCLUSIONES

The analysis presented in this paper strongly demonstrates the intrinsic relationship between Mexico's economic and financial stability and the health of its ecosystems. Biodiversity and ecosystem services underpin a significant share of national production, employment and the national loan portfolio, underscoring the urgency of integrating environmental criteria into financial supervision and public policymaking. The degradation of these services not only threatens environmental sustainability, but also poses systemic economic risks that impact along supply chains and key sectors of the economy.

The multidisciplinary methodology employed, which combines economic models, georeferenced data, and physical and transition risk simulations, provides a solid basis for identifying and prioritizing interventions. From stress tests based on ecological scenarios to green financing mechanisms, the proposed recommendations seek to strengthen the financial system's capacity to respond to environmental challenges. These actions are necessary not only to mitigate the consequences of water crises or biodiversity losses, but also to take advantage of opportunities in a world where sustainability can become a determining factor for the increase in the value of assets and companies.

In conclusion, integrating biodiversity-related risks and opportunities into financial and policy decision-making is not an option, but an urgent need. This approach will not only ensure greater economic resilience, but will also position Mexico as a leader in financial sustainability on the global stage.

REFERENCES

- Calice et al. (2021). “Climate-related Financial Risks and Bank Lending.”
- Convention on Biological Diversity (2022). Kunming-Montreal Global Biodiversity Framework.
- Dasgupta, P. (2021). The Economics of Biodiversity: The Dasgupta Review.
- Environmental Reports (OECD, 2020).
- Global Assessment Report on Biodiversity and Ecosystem Services (IPBES, 2019).
- Global Risks Report WEF (2023). World Economic Forum.
- IFC Performance Standards (2012). International Finance Corporation.
- Natural Capital Protocol (2016). Natural Capital Coalition.
- Network for Greening the Financial System Reports & Publications (NGFS, 2022).
- Organization of the United Nations for Food and Agriculture (FAO, 2020).
- Taskforce on Nature-related Financial Disclosures (TNFD, 2021).
- The Economics of Ecosystems and Biodiversity (TEEB, 2010).
- United Nations Environment Programme (PNUMA, 2021).
- “Mainstreaming the Economics of Nature” (Sukhdev et al., 2010).
- World Bank & Bank Negara Malaysia Reports (WB & BNM, 2022).

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