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Bridging nature and finance: Financial and macroeconomic determinants of biodiversity loss in emerging markets

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Abstract: This study examines the financial and macroeconomic factors affecting biodiversity loss in 51 emerging markets using the number of threatened species in biodiversity ecosystems for the years 2018 and 2022. We find that bank branch expansion and private sector credit expansion are associated with higher biodiversity loss, while financial inclusion in terms of increased number of bank depositors is associated with lower biodiversity loss. High inflation and low unemployment also increase biodiversity loss. The implication of the findings is that man-made activities in the financial sector and in the economy affect biodiversity loss in emerging market countries.

Keywords: biodiversity risk, biodiversity loss, financial inclusion, inflation, unemployment, economic growth, capital adequacy ratio, nonperforming loans, domestic private credit, determinant.

1. Introduction

Biodiversity loss has become a central concern in the finance and economics literature, reflecting the increasing recognition that natural systems underpin economic activity and financial stability (Karolyi & Tobin de la Puente, 2023). Firms depend on ecosystem services including pollination, water regulation, nutrient cycling and soil fertility to sustain production (Becker et al., 2025). When these services deteriorate, the functioning of supply chains, agricultural productivity and industrial operations becomes increasingly vulnerable (Farber et al., 2002). At the same time, economic activity contributes directly to ecosystem degradation through unsustainable resource extraction, deforestation, industrial expansion and urbanisation, which accelerate the loss of biodiversity (Hudson, 2024).

These dynamics are especially pronounced in emerging markets, where rapid economic development intensifies pressures on ecosystems and natural capital. Many of these economies face simultaneous challenges related to climate change, extensive land conversion and weak environmental governance (Joof et al., 2023). Industrialisation, infrastructure development and agricultural expansion have transformed biodiverse landscapes into commercial and urban areas at an accelerating pace (Sun et al., 2025). These processes reduce carbon sequestration, impair water filtration and heighten risks to food security, thereby eroding the ecological foundations of long-term economic growth (Giglio et al., 2024). With the exception of a few cases such as China, progress in protecting biodiversity remains limited due to insufficient prioritisation of conservation within national development strategies (Zhang et al., 2024).

Financial systems play a central role in shaping these outcomes. The International Monetary Fund emphasises financial inclusion, access to credit and macroeconomic stability as key enablers of economic development in emerging markets (Ehigiamusoe & Samsurijan, 2021). Although these factors are associated with poverty reduction and

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economic expansion, their environmental implications are not well understood. Expansion in financial access, improvements in intermediary activity and stable macroeconomic conditions may facilitate investment in land intensive, resource consuming and environmentally disruptive activities. Yet the links between financial sector dynamics and biodiversity loss remain largely unexplored.

This study investigates how financial determinants (such as financial inclusion, financial stability and financial intermediation) alongside macroeconomic conditions relate to biodiversity outcomes in emerging market economies. We posit that easy access to finance, robust banking systems and favourable macroeconomic environments may unintentionally accelerate biodiversity loss by enabling deforestation, industrial development and urban expansion.

To examine this argument, we analyse biodiversity indicators for 2018 and 2022 across multiple taxonomic groups. We utilize the generalized linear method regression and the median quantile regression methods. The results indicate that bank branch expansion and higher level of private sector credit increase biodiversity loss while increased number of bank depositors decreases biodiversity loss. High inflation and unemployment also appear to increase biodiversity loss.

The study contributes to the literature in three ways. First, it offers novel empirical evidence on the financial and macroeconomic drivers of biodiversity loss in emerging markets, an area where systematic analysis remains scarce. Second, it highlights that policies promoting financial inclusion, bank stability and macroeconomic stability may generate unintended ecological pressures when environmental safeguards are weak. Third, it underscores the importance of integrating biodiversity considerations into financial regulation and macroeconomic policy frameworks to ensure that economic development does not compromise ecosystem resilience.

The remainder of the paper proceeds as follows. Section two reviews the theoretical and empirical literature. Section three outlines the research design. Section four presents the results and discussion. Section five concludes.

2. Theory and Literature review

2.1. The Finance–Biodiversity Nexus in Emerging Markets

Biodiversity loss is increasingly recognised as a key component of nature-related financial risk and is closely connected to climate change. The degradation of ecosystems reduces carbon sequestration capacity, weakens water regulation and decreases soil productivity, thereby amplifying both the physical and transition risks associated with climate instability (Deutz et al., 2020; Flammer et al., 2025). According to the Network for Greening the Financial System and the Taskforce on Nature-related Financial Disclosures, biodiversity and climate risks reinforce each other. Biodiversity loss contributes to climate disruption, while climate change accelerates the deterioration of ecosystems (NGFS, 2026). Together, these interactions represent systemic risks for macroeconomic and financial stability (Garel et al., 2024; IMF, 2024).

From the perspective of financial systems, biodiversity can be conceptualised as a form of natural capital that supports economic activity by providing essential ecosystem services, including pollination, water purification and climate regulation (Costanza et al., 1997; Daily, 2000). When biodiversity declines, the productive capacity of the economy and the resilience of financial systems are weakened. Financial institutions are exposed to biodiversity loss through their credit decisions, investment portfolios and underwriting activities, which both depend on and influence ecosystem services. This dual exposure reflects the principle of double materiality, according to which financial actors are simultaneously affected by and contribute to biodiversity degradation (OECD, 2023; Schrapffer et al., 2024).

In emerging markets, the links between finance, biodiversity and climate are particularly strong. Rapid industrialisation, urbanisation and extensive resource extraction, often combined with limited regulatory enforcement, create feedback loops between economic development and ecosystem degradation. Although financial development and inclusion support growth and poverty reduction, they may also intensify land-use change, deforestation and habitat fragmentation (Calice, 2023; Joof et al., 2023; Sun et al., 2025). In addition, the limited availability of biodiversity-oriented financial instruments and the insufficient integration of nature-related risks into prudential supervision constrain the ability of these economies to address biodiversity pressures. As a result, emerging markets frequently encounter a development–degradation paradox, where financial expansion facilitates growth while contributing to biodiversity decline.

Biodiversity finance has emerged as a response to this challenge, aiming to mobilise public and private capital to support conservation and ecosystem restoration. However, markets for biodiversity-linked instruments, such as biodiversity credits, sustainability-linked loans and green bonds, remain at an early stage of development, especially in emerging markets (Flammer et al., 2025; Karolyi & Tobin-de la Puente, 2023). Although the global biodiversity financing gap is estimated to exceed USD 700 billion annually (Deutz et al., 2020), empirical evidence on the financial and macroeconomic determinants of biodiversity loss in developing and emerging economies is still limited. A better understanding of these determinants is essential for designing financial mechanisms and regulatory frameworks that align financial stability, monetary and fiscal policies, and biodiversity conservation (Calice, 2023; IMF, 2024; OECD, 2023).

2.2. Financial and Macroeconomic Determinants of Biodiversity Loss

Biodiversity loss is increasingly recognised as a systemic concern for both the real economy and the financial sector (Hudson, 2024). Financial systems depend on ecosystem functions that support production and consumption, while credit allocation, investment decisions and policy incentives can, in turn, influence environmental outcomes. This interdependence is consistent with Natural Capital Theory, which conceptualises biodiversity and ecosystems as a stock of natural capital that generates essential services including water purification, pollination and climate regulation (Turner et al., 2008). When biodiversity declines, the capacity of natural capital to provide these services diminishes, with potential implications for long-term economic productivity and financial stability.

In emerging markets, these dynamics are intensified by development paths that often prioritise short-term economic expansion over ecosystem protection. Many of these countries rely on resource-intensive growth models characterised by land conversion, natural resource extraction and large-scale infrastructure development, frequently in contexts where institutional safeguards are limited (Schoneveld & Zoomers, 2015). As financial deepening progresses through increased credit access, broader financial inclusion and expanded infrastructure finance, it may accelerate land-use change, deforestation and biodiversity loss (Ali et al., 2024).

The concept of double materiality is also relevant for biodiversity. Financial institutions and markets are exposed to risks stemming from ecosystem degradation, but they can also contribute to these risks by financing activities with adverse environmental impacts (OECD, 2023; Schrapffer et al., 2024). This dual exposure increases the likelihood that biodiversity loss becomes a financial stability concern (Busch et al., 2024). Recent policy initiatives, including those of the Network for Greening the Financial System and the Taskforce on Nature-related Financial Disclosures, acknowledge this challenge and highlight the need to integrate nature-related risks into prudential regulation and supervisory practices (NGFS, 2026).

The field of biodiversity finance seeks to address these issues by mobilising capital for conservation and ecosystem restoration. However, the global biodiversity financing gap—estimated at more than USD 700 billion per year—remains a significant barrier, particularly for emerging markets (Hutchinson & Lucey, 2024; Zu Ermgassen et al., 2025).

At the same time, innovative financial instruments such as biodiversity-linked loans, nature-positive bonds and sustainability-linked credit lines are increasingly being explored as mechanisms to align financial returns with conservation objectives (Naffa, 2025).

Overall, the relationship between financial systems and biodiversity outcomes represents an important area of research. Understanding how financial decisions contribute to or mitigate biodiversity loss is essential, particularly in emerging markets where biodiverse ecosystems coincide with rapid financial and economic expansion. Embedding biodiversity considerations into financial regulation, portfolio management and macro-financial policy can support development strategies that recognise nature-related risks and encourage financial solutions aimed at strengthening ecosystem resilience.

2.3. Hypothesis development

The interaction between finance and biodiversity in emerging economies is complex and multidirectional (Cosma et al., 2023). Expanding access to financial services promotes economic inclusion and entrepreneurship, but it can also generate environmental externalities when credit growth outpaces regulatory capacity (Ho & Wong, 2023) The rapid diffusion of banking infrastructure and credit opportunities often stimulates agricultural expansion, construction, and industrial activity in regions where environmental oversight is limited (Joof et al., 2023). As a result, deforestation, habitat fragmentation, and land-use change tend to increase in tandem with financial deepening. Evidence from emerging economies suggests that when credit flows to resource-intensive sectors such as agriculture, energy, or construction, the developmental benefits of inclusion may coincide with accelerating biodiversity loss (Ali, et al., 2024).

H1. Higher levels of financial inclusion are positively associated with greater biodiversity loss in emerging market economies.

Financial stability and intermediation are equally double-edged. A sound and profitable banking sector promotes investment and growth, yet stable financial systems may inadvertently amplify biodiversity degradation when capital is directed toward environmentally intensive projects (Calice, 2023). In many emerging markets, well-capitalised banks finance infrastructure, extractive, and industrial ventures that depend heavily on ecosystem services and natural resource exploitation (Garel et al., 2024). Despite the rise of sustainability frameworks, financial institutions have been slow to internalise the ecological externalities of their lending and investment portfolios (Hutchinson & Lucey, 2024). The resulting misalignment between financial performance and environmental sustainability implies that stronger intermediation can coincide with higher ecological pressure, especially where supervisory frameworks fail to account for biodiversity-related risks.

H2. Greater financial stability and intermediation—reflected by higher capital adequacy and expanded private-sector credit—are positively associated with biodiversity loss.

At the macroeconomic level, the drivers of biodiversity loss are reinforced by growth-oriented policies. Periods of strong GDP expansion, low inflation, and high employment stimulate consumption, production, and infrastructure development, all of which intensify natural resource extraction and land conversion. In emerging economies, these dynamics often unfold within fragile ecosystems, where regulatory and institutional constraints limit the enforcement of environmental protection (Ho & Wong, 2023; Joof et al., 2023). Without financial instruments explicitly designed to channel investment toward conservation or restoration, economic expansion remains structurally biased toward activities that degrade biodiversity (Cosma et al., 2023; Deutz et al., 2020).

H3. Favorable macroeconomic conditions—characterised by low inflation, strong economic growth, and low unemployment—are positively associated with biodiversity loss.

Taken together, these relationships illustrate a persistent paradox within emerging markets: the very conditions that underpin financial development and macroeconomic stability may simultaneously erode the natural capital base on which future growth depends. Understanding these mechanisms is crucial for assessing how financial systems can internalise biodiversity risks and for identifying innovative channels—such as biodiversity-linked instruments or conservation finance—through which capital markets can support nature-positive development (Cosma et al., 2023; Flammer et al., 2025; Karolyi & Tobin-de la Puente, 2023).

3. Research methodology

3.1. Data and sample

Country-level annual biodiversity, financial and economic data were collected from the World Bank's world development indicators. See Table 1 for variable description. The countries included in the sample were selected based on availability of biodiversity loss data. Data were collected for 51 countries that have sufficient data for the biodiversity indicators used in the study. Table 2 presents the list of emerging market countries. The study covers 2018 and 2022 only. The key biodiversity indicators are available in the World Bank's World Development Indicators database for these years only.

Table 1. Variable description and source

Variable	Indicator Name	Definition	Source
		Biodiversity indicators (the dependent variables)	
BS	Bird species, threatened.	Threatened bird species are the number of bird species classified by the IUCN as endangered, vulnerable, rare, indeterminate, out of danger, or insufficiently known.	International Union for Conservation of Nature (IUCN), World Bank database.
FS	Fish species, threatened.	Threatened fish species are the number of fish species classified by the IUCN as endangered, vulnerable, rare, indeterminate, out of danger, or insufficiently known.	International Union for Conservation of Nature (IUCN), World Bank database.
MS	Mammal species, threatened.	Mammal species are mammals excluding whales and porpoises that are classified by the IUCN as endangered, vulnerable, rare, indeterminate, out of danger, or insufficiently known.	International Union for Conservation of Nature (IUCN), World Bank database.
PS	Plant species (higher), threatened.	Higher plants are native vascular plant species that are classified by the IUCN as endangered, vulnerable, rare, indeterminate, out of danger, or insufficiently known.	International Union for Conservation of Nature (IUCN), World Bank database.
BDI	Biodiversity loss index	Principial component analysis of the threatened plant species (PS), threatened bird species (BS), threatened mammal species (MS), and threatened fish species (FS)	Authors' construct
		Financial determinants / indicators (independent variables)	
ATM	Automated teller machines (ATMs) (per 100,000 adults)	This is a measure of financial inclusion. Automated teller machines (ATMs) are electromechanical devices which enable customers of financial institutions to perform financial transactions	World Bank's world development indicators
CB	Commercial bank branches (per 100,000 adults)	This is a measure of financial inclusion. Commercial bank branches are retail locations of resident commercial banks that provide financial services to customers	World Bank's world development indicators
DP	Depositors with commercial banks (per 1,000 adults)	This is a measure of financial inclusion. Depositors with commercial banks are the reported number of deposit account holders at commercial banks within the reporting jurisdiction for every 1,000 adults.	World Bank's world development indicators

BC	Bank capital to assets ratio (%)	This is a measure of financial stability that evaluates the financial strength of deposit takers by comparing Tier 1 capital to total assets.	World Bank's world development indicators
NP	Bank nonperforming loans to total gross loans (%)	This is a measure of financial stability. The indicator measures the proportion of a deposit taker's loan portfolio that is impaired or at risk of default. It is a measure of financial stability.	World Bank's world development indicators
DC	Domestic credit to private sector by banks (% of GDP)	Domestic credit to private sector by banks refers to financial resources provided to the private sector by other depository corporations (deposit taking corporations except central banks)	World Bank's world development indicators
		Macroeconomic variables / indicators	
INF	Inflation, consumer prices (annual % growth)	Inflation as measured by the consumer price index	World Bank's world development indicators
GDPR	GDP (annual % growth)	Gross domestic product is the total income earned through the production of goods and services in an economic territory during an accounting period.	World Bank's world development indicators
UNEMP	Unemployment, total (% of total labor force) (modeled ILO estimate)	Unemployment refers to the share of the labor force that is without work but available for and seeking employment.	World Bank's world development indicators

3.2. Estimation model

The model used to estimate the financial and macroeconomic determinants of biodiversity loss is similar to the models used in existing studies when investigating the determinants of climate change (Becker et al, 2025; Xing and Wang, 2025; Giglio et al, 2024). The model is estimated as follows.

$$(Biodiversity\ loss\ variables)_{i,t} = \beta_0 + \beta_1(Financial\ Determinants)_{i,t} + \beta_2(Macroeconomic\ Determinants)_{i,t} + e_{i,t} \quad (1)$$

The model is expanded below

$$Biodiversity\ loss\ (BDI, FS, PS, MS, BS)_{i,t} = \beta_0 + \beta_1 ATM_{i,t} + \beta_2 CB_{i,t} + \beta_3 DP_{i,t} + \beta_4 BC_{i,t} + \beta_5 NP_{i,t} + \beta_6 6DC_{i,t} + \beta_7 GDPR_{i,t} + \beta_8 INF_{i,t} + \beta_9 UNEMP_{i,t} + e_{i,t} \quad (2)$$

Where i, t represents country and year. The description of the variables in the model is presented in Table 1. εit is the error term of the model.

3.3. Estimation procedure

The main estimation method used in this study to investigate the financial and macroeconomic determinants of biodiversity loss is the generalized linear model (GLM). The generalized linear model regression method takes into account the potential nonlinearity between the response variable and the predictor variable through a link function (Thompson and Baker, 1981). The GLM method is superior to the ordinary least squares (OLS) because it is more flexible, it can handle a wide range of response variable types and error distributions, and it can handle non-normal data distribution. Another major reason why we used the GLM method is because the short sample period of the data makes it difficult for us to use more robust econometric techniques, like the generalized method of moments regression method, which require taking the lag of the dependent variable and would therefore make the estimation impossible to execute due to the few data points.

The GLM approach is also appropriate for both the threatened-species variables and the PCA-based biodiversity loss index because GLM relaxes standard regression assumptions by modeling the expected response through a link function rather than directly. In the GLM estimation, the selected family function is the 'Guassian/normal' family function, while the selected link function is the "identity" link function.

Finally, the biodiversity loss index is constructed using principal component analysis. It constructs PCA using standard linear algebra by transforming a set of correlated variables into a smaller set of uncorrelated variables (the principal components). It achieves this by (i) undertaking a data standardization process, which centers or standardizes the original variables so they have a mean of 0 and a standard deviation of 1, (ii) ensuring that the variables with larger numeric scales do not disproportionately dominate the analysis, (iii) calculating the covariance matrix for unstandardized data or the correlation matrix for standardized data to capture how variables change together, (iv) using linear algebra to find the eigenvalues (λ) and eigenvectors (v) of this matrix, (v) sorting the eigenvectors in descending order of their eigenvalues, (vi) ensuring that the original data is then projected onto these eigenvectors to create weighted, artificial variables known as the principal components.

3.4. Variable justification

This study used five dependent variables, namely the threatened mammal species variable (MS), the threatened plant species variable (PS), the threatened fish species variable (FS), the threatened bird species variable (BS) threatened mammals, and the biodiversity loss index, variable which is derived from the principal component analysis of the BS, MS, PS and FS variables. These variables measure the stock of threatened species rather than the actual change in biodiversity over time. However, due to lack of appropriate data to measure the actual change in biodiversity over time, we use these five indicators as proxies for biodiversity loss. We expect that an increase in the stock of a threatened species (e.g., mammal, bird, plant or fish) would signal biodiversity loss for that species because it means that a larger portion of that species is at an elevated risk of extinction, reflecting a severe decline in overall global biodiversity.

3.4.1. Financial determinants / variables

Regarding financial stability, the literature identify bank capital adequacy ratio (BC) and the nonperforming loan ratio (NP) as crucial proxies for financial stability (Giraldo et al, 2024, Nguyen Thi Truc and Le Thanh, 2025; Ozili, 2025). Accordingly, we introduce the BC and NP variables into the model as financial stability variables to control for the potential effect of financial stability on biodiversity loss. Intuitively, we predict that an increase in bank stability activities, such as the acquisition or sale of land and properties by banks to raise new capital or banks' loan recovery enforcement activity to minimize non-performing loans, can put pressure on environment resources and have an adverse effect on biodiversity. Therefore, a positive relationship is expected between the two financial stability variables and the biodiversity loss indicators.

Regarding financial intermediation, the literature identifies the ratio of domestic private credit by banks to GDP as a crucial indicator of the level of financial intermediation (Li et al, 2024). Accordingly, we introduce the DC variable into the model as a financial intermediation variable to control for the potential effect of financial intermediation on biodiversity loss. Intuitively, we predict that higher financial intermediation via greater supply of domestic private credit by banks will stimulate private firms to expand and acquire new lands for commercial and industrial uses. This would lead to the destruction of natural habitats after conversion of natural habitats to commercial use, thereby leading to biodiversity loss. Therefore, a positive relationship is expected between the financial intermediation variable and the biodiversity loss indicators.

Regarding financial inclusion, the literature identify the number of ATMs per 100,000 adults (ATM), the number of commercial banks per 100,000 adults (CB) and the number of depositors per 1,000 adults (DP) as crucial proxies for financial inclusion (Khan and Sahu, 2025; Ozili, 2024). Accordingly, we introduce the CB, DP, and ATM variables into the model as financial inclusion variables to control for the potential effect of financial access or financial inclusion on biodiversity loss. We predict that an increase in financial inclusion activities will increase biodiversity loss. This is because deforestation to open a new commercial bank branch in rural locations or the clearing of natural habitats in urban or rural areas to install an automated teller machine or to open a commercial bank branch will adversely affect the natural habitats and species residing in the locations that have now being converted to a commercial bank branch or an ATM stand, thereby leading to biodiversity loss. Therefore, a positive relationship is expected between the financial inclusion variables and the biodiversity loss indicators.

3.4.2. Macroeconomic determinants / variables

The INF, UNEMP and GDPR variables are the crucial macroeconomic variables which controls for the potential effect of fluctuating economic conditions on biodiversity loss. We predict that improvements in macroeconomic condition will adversely affect biodiversity loss. This is because low inflation, low unemployment and high gross domestic product growth are often associated with accelerated economic expansion, business expansion, rapid industrialization, deforestation to create new factories and the construction of new infrastructure (Roncaglia de Carvalho et al, 2018). This, in turn, will lead to the conversion of natural habitats, bio-rich land areas and protected lands to commercial use thereby destroying species and leading to biodiversity loss. Therefore, a positive relationship is expected between the three macroeconomic variables and the biodiversity loss indicators.

3.5. Descriptive statistics and correlation

The descriptive statistics in Table 2 show that the top countries with high biodiversity loss, as measured by the biodiversity loss index, include Tanzania (5.31), Brazil (4.7) Ecuador (3.15), Madagascar (2.97), Colombia (2.65), Malaysia (2.34), Peru (1.69) and Thailand (1.37). In contrast, the top countries with better biodiversity conservation (or low biodiversity loss index) include Botswana (-0.94), Maldives (-0.95), Poland (-0.97), Samoa (-0.97), Moldova (-0.99), Latvia (-1.02), Estonia (-1.06) and Lesotho (-1.1). In the disaggregated biodiversity index, Table 2 also show that the threatened fish species variable (FS) is higher in Brazil and Turkiye while the FS variable is very low in Paraguay and Lesotho, the threatened mammal species variable (MS) is higher in Tanzania and Brazil and is very low in Estonia and Latvia, the threatened plant species variable (PS) is higher in Madagascar and Malaysia and is very low in the UAE, Maldives and Kuwait, the threatened bird species variable (BS) is higher in Brazil and Tanzania and very low in Maldives.

The correlation analysis in Table 3 shows that the BDI variable has a negative correlation with the BC, DP, INF, GDPR and UNEMP variables. This suggests that a high bank capital adequacy ratio, higher number of bank depositors, a high inflation rate, a high rate of economic growth and a high unemployment rate are correlated with lower biodiversity loss. In contrast, the BDI variable has a positive correlation with the NP, CB, ATM and DC variables, indicating that a high bank nonperforming loans ratio, a high number of commercial bank branches, higher ATM penetration, and higher levels of financial intermediation are correlated with greater biodiversity loss. The variance inflation factor in Appendix A1 in the appendix shows that the centered VIF values for all the variables are below the value of 2, indicating that multicollinearity is not a major problem in our model.

Table 2. Full sample Descriptive statistics

S/N	Countries	BDI	BC	NP	BS	FS	MS	PS	CB	DP	ATM	DC	INF.	GDPR.	UNEMP.
1	Albania	-0.63	8.87	7.61	8	52	3.5	4.5	18.31	1092.53	33.56	30.67	4.38	4.25	11.54
2	Bangladesh	-0.05	5.72	9.31	36	52	38	29	8.86	882.75	10.71	39.36	6.62	7.21	4.52
3	Belize	-0.52	11.45	13.86	7	57	10	65	16.87	753.4	44.77	43.73	3.27	5.04	9.01
4	Botswana	-0.94	8.93	4.59	17	2	11	3	8.1	771.04	38.05	32.24	7.45	4.84	21.64
5	Brazil	4.7	8.94	2.62	165	226.5	88.5	952	17.75	748.63	102.14	65.41	6.47	2.4	10.78
6	Colombia	2.65	10.02	2.95	114	141	60.5	593	13.87	1605.66	40.89	45.01	6.71	4.95	9.95
7	Comoros	-0.86	10.45	18.45	13.5	17.5	5.5	12	4.19	154.38	5.91	16.23	7.34	3.12	3.93
8	Costa Rica	0.39	8.81	2.11	26	104	11.5	231	17.71	1525.4	68.77	55.51	5.25	3.58	10.17
9	Croatia	-0.31	11.15	7.37	15	72	9.5	9.5	28.09	1488.15	136.59	52.4	6.14	5.1	7.57
10	Cyprus	-0.8	7.49	13.59	8	31.5	6.5	22.5	31.35	1320.36	36.58	103	4.92	7.27	7.66
11	Djibouti	-0.71	6.71	11.18	13.5	31.5	11	3	8.38	176.33	13.96	20.73	2.66	4.97	26.23
12	Dominican Republic	-0.55	24.82	1.22	17	38	6.5	68.5	11.63	804.88	37.5	26.45	6.19	6.17	5.68
13	Ecuador	3.15	11.51	3.34	96	80	48	1944	9.19	747.14	35.66	43.17	1.62	3.46	3.62
14	El Salvador	-0.74	9.18	1.82	8	34	6	55	12.14	826.59	36.91	52.03	4.14	2.68	3.5
15	Equatorial Guinea	-0.38	6.98	46.17	4.5	63	23.5	131.5	5.81	265.06	11.15	11.09	2.92	-1.51	8.08
16	Estonia	-1.06	11.11	1.18	10	4.5	1	1	8.25	2102.91	63.63	58.99	11.42	1.24	5.49
17	Georgia	-0.83	12.26	2.1	14.5	12	8.5	66.5	31.56	1135.87	88.77	58.39	7.26	8.51	12.14
18	Ghana	0	10.01	16.49	24	72.5	22	123.5	7.03	768.03	10.94	12.03	19.53	5	3.04
19	Hungary	-0.9	9.96	3.13	13.5	10	4.5	44	15.83	1168.9	59.04	33.98	8.73	4.88	3.63
20	Israel	-0.26	6.98	0.96	18.5	67	15.5	31	15.96	1085.37	128.86	67.81	2.61	5.13	3.81
21	Italy	-0.26	6.11	5.59	18	62	8.5	112	36.99	732.28	90.72	71.88	4.67	2.82	9.3
22	Kuwait	-0.81	12.13	1.52	11	27.5	7	0	12.61	1286.63	69.18	47.08	2.26	4.75	2.17
23	Kyrgyz Republic	-0.93	12.31	9.88	15	7.5	5	13	7.86	904.86	41.21	21.95	7.73	6.36	4.66
24	Latvia	-1.02	10.25	3.79	12	6	1	0.5	9.89	1298.43	58.79	34.45	9.92	3.11	7.11
25	Lesotho	-1.1	11.38	3.99	8.5	1	4	4.5	3.62	405.73	13.93	20.63	6.51	0.45	16.62
26	Madagascar	2.97	6.51	7.82	37	119	127	2002.5	2.6	200.35	2.99	15.72	8.38	3.68	2.74
27	Malawi	-0.53	8.66	4.17	19.5	36.5	10	46.5	2.11	163.41	4.6	7.53	16.69	2.64	5.02
28	Malaysia	2.34	8.03	1.59	65	135	75.5	1022	9.08	691.3	50.28	116.65	2.13	6.94	3.62
29	Maldives	-0.95	18.69	10.48	0	32.5	2	0	14.64	1297.15	39.34	29.34	1.1	11.2	4.63

30	Malta	-0.86	7.51	3.43	5.5	32.5	2.5	4	25.71	1603.92	47.22	68.96	3.66	4.84	3.71
31	Mauritius	-0.71	9.69	5.72	12	25.5	7	97	15.86	1902.25	42.74	73.25	6.99	6.35	6.37
32	Moldova	-0.99	13.21	9.47	11.5	8	5	2	32.81	1445.21	54.48	20.88	15.89	-0.26	1.07
33	Namibia	-0.29	10.11	4.55	32.5	40	15	38	10.41	1106.62	74.26	53.62	5.19	3.23	19.75
34	Nicaragua	-0.23	8.43	1.98	18	68.5	8	84.5	8.59	380.01	21.6	31.09	7.71	0.09	5.08
35	Nigeria	0.26	7.23	7.84	22	88	33	230.5	4.31	1399.22	15.42	9.85	15.47	3.12	4.45
36	North Macedonia	-0.9	10.79	3.91	13.5	13	6.5	5	25.72	1174.19	65.86	50.34	7.83	2.82	17.84
37	Pakistan	0.12	5.39	7.26	33	81.5	24.5	16	10.55	420.26	11.12	15.68	12.48	5.46	4.69
38	Paraguay	-0.78	8.68	2.73	27.5	0	10.5	21	11.18	678.63	29.94	47.79	6.87	1.69	6.49
39	Peru	1.69	10.39	3.69	106	71	52	448	6.26	1122.79	123.8	44.79	4.92	3.39	3.89
40	Poland	-0.97	7.64	3.15	12	8	4	13.5	26.19	1245.31	69.63	45.61	8.12	5.75	3.32
41	Rwanda	-0.71	13.62	3.89	20	7	24	87.5	4.41	313.54	4.6	21.99	8.69	8.34	12.92
42	Samoa	-0.97	12.23	4.29	5.5	21	2	6	22.71	1031.33	52.44	48.72	7.58	0.83	6.85
43	Solomon Islands	-0.49	12.86	8.31	22.5	33.5	21.5	34.5	3.95	593.62	13.88	20.52	4.49	0.08	1.1
44	Tanzania	5.31	8.18	47.5	199	43	827	2.43	409.53	6.13	13.87	3.92	5.03	1.89	10.54
45	Thailand	1.37	10.54	2.96	64	129.5	61.5	195.5	10.03	1346.66	106.94	116.59	-0.27	3.4	0.85
46	Turkiye	0.57	9.5	2.83	21	139.5	18.5	124	15.75	1825.6	81.89	54.87	44.32	4.45	10.71
47	Uganda	0.02	14.58	4.21	31.5	61	31.5	105	2.49	455.12	3.96	12.88	4.91	5.45	3.07
48	United Arab Emirates	-0.69	11.75	5.9	13	36.5	8	0	9.6	1215.35	61.59	67.37	4.18	4.53	2.55
49	Uruguay	-0.32	9.94	2.1	22	58	9.5	22	9.83	1121.6	211.05	25.76	8.36	2.33	8.11
50	Uzbekistan	-0.84	11.25	2.41	19	8	10	16	44.07	689.65	55.63	26.57	14.49	5.78	4.92
51	Zambia	-0.63	10.65	7.97	21	23	13	40	3.24	252.14	9.63	10.93	9.24	4.62	5.51
	Aggregate statistic	BD	BC	NP	BS	FS	MS	PS	CB	DP	ATM	DC	INF	GDPR	UNEMP
	Mean	0	10.19	7.16	30.33	50.8	35.79	180.06	21.64	935.93	49.94	41.28	7.67	4.09	7.29
	Median	-0.56	9.68	3.94	17.5	40.5	10	30	11.07	954.25	42.35	36.95	5.4	4.11	5.34
	Maximum	6.32	40.01	55.41	219	360	1010	2894	517	2182.91	301.43	135.24	72.31	13.83	26.27
	Minimum	-1.11	1.15	0.71	0	0	1	0	1.93	5.61	2.86	3.49	-1.61	-6.24	0.72
	Std. Dev.	1.5	4.05	9.37	39.36	51.85	118	447.02	58.02	510.26	43.22	27.23	8.91	3.08	5.43
	Observations	102	102	102	102	102	102	102	102	102	102	102	102	102	102

Table 3. Pearson correlation matrix of the variables

Variable	BD	BS	FS	MS	PS	BC	NP	CB	DP	ATM	DC	INF	GDPR	UNEMP
BD	1.00													

BS	0.89***	1.00												
	(0.00)	-----												
FS	0.72***	0.47***	1.00											
	(0.00)	(0.00)	-----											
MS	0.66***	0.72***	0.12	1.00										
	(0.00)	(0.00)	(0.21)	-----										
PS	0.68***	0.41***	0.55***	0.11	1.00									
	(0.00)	(0.00)	(0.00)	(0.26)	-----									
BC	-0.17*	-0.11	-0.18*	-0.12	-0.10	1.00								
	(0.09)	(0.27)	(0.07)	(0.23)	(0.33)	-----								
NP	0.22**	0.24**	-0.05	0.57***	-0.09	-0.14	1.00							
	(0.02)	(0.01)	(0.61)	(0.00)	(0.38)	(0.17)	-----							
CB	0.48***	0.58***	-0.04	0.95***	-0.08	-0.08	0.56***	1.00						
	(0.00)	(0.00)	(0.69)	(0.00)	(0.40)	(0.40)	(0.00)	-----						
DP	-0.17*	-0.18*	0.08	-0.29***	-0.12	0.05	-0.38***	-0.19*	1.00					
	(0.09)	(0.08)	(0.42)	(0.00)	(0.22)	(0.63)	(0.00)	(0.06)	-----					
ATM	0.04	0.08	0.18*	-0.12	-0.05	0.01	-0.31***	-0.05	0.47***	1.00				
	(0.69)	(0.43)	(0.07)	(0.24)	(0.60)	(0.94)	(0.00)	(0.62)	(0.00)	-----				
DC	0.08	0.05	0.24**	-0.16	0.10	-0.10	-0.31***	-0.12	0.47***	0.42***	1.00			
	(0.41)	(0.65)	(0.01)	(0.12)	(0.30)	(0.31)	(0.00)	(0.23)	(0.00)	(0.00)	-----			
INF	-0.01	-0.09	0.16	-0.05	-0.05	-0.10	-0.11	-0.05	0.22**	-0.03	-0.21**	1.00		
	(0.89)	(0.38)	(0.11)	(0.60)	(0.62)	(0.33)	(0.26)	(0.63)	(0.03)	(0.75)	(0.04)	-----		
GDPR	-0.04	-0.10	0.07	-0.10	0.02	0.05	-0.17*	-0.08	0.16*	0.03	0.11	-0.02	1.00	
	(0.69)	(0.33)	(0.50)	(0.33)	(0.81)	(0.61)	(0.08)	(0.42)	(0.10)	(0.76)	(0.27)	(0.85)	-----	
UNEMP	-0.05	0.02	-0.10	0.05	-0.14	-0.10	0.07	0.09	-0.12	0.00	-0.06	-0.01	0.00	1.00
	(0.59)	(0.85)	(0.33)	(0.64)	(0.15)	(0.33)	(0.51)	(0.38)	(0.21)	(0.98)	(0.53)	(0.90)	(0.98)	-----

This table reports the Pearson correlation coefficients for the variables. Probability values are in parenthesis. ***,**,* represent statistical significance at the 1%, 5% and 10% levels.

4. Regression result

This section presents the discussion of the results for the effect of financial and economic factors on biodiversity loss. The regressors are estimated on five dependent variables, namely, the biodiversity loss index (BDI), the threatened fish species variable (FS), the threatened mammal species variable (MS), the threatened plant species variable (PS) and the threatened bird species variable (BS). We begin the analysis by estimating the financial factors affecting biodiversity loss in section 4.1, followed by the economic factors affecting biodiversity loss in section 4.2. Thereafter, we examine the combined financial and economic factors affecting biodiversity loss in section 4.3.

4.1. Financial determinants of biodiversity loss

The results are reported in Table 4. The CB variable is positive and significant in the biodiversity loss index (BDI) model in column 1 and in the threatened mammal and bird species models in columns 4 and 5, suggesting a positive association between commercial bank branch expansion and biodiversity loss particularly among threatened mammal and bird species. This result supports first hypothesis (H1). A potential explanation for this result is that bank branch expansion to new areas can be directly associated with localised habitat destruction which threatens mammal species. Also, as banks expand to new locations, it can lead to higher carbon emissions from financed bank projects, thereby threatening bird species.

The economic significance of the result is that a one percent increase in the number of bank branches per 100,000 adults is associated with an increase in biodiversity loss by 0.013%, increase loss of mammal species by 1.88% and increase loss of bird species by 0.42%.

The DP variable is negative and significant in the biodiversity loss index (BDI) model in column 1 and in the threatened plant, mammal and bird species models in columns 3, 4 and 5, suggesting that higher number of bank depositors is associated with fewer biodiversity loss and a decrease in loss of plant, mammal and bird species. A potential explanation for this result could be that higher levels of financial inclusion is beneficial for biodiversity. The economic significance of the result is that a one percent increase in the number of depositors is associated with a decrease in biodiversity loss by 0.0006%, decrease in loss of plant species by 0.204%, decrease in loss of mammal species by 0.024%, and decrease in loss of plant species by 0.017%.

The DC variable is positive and significant in the biodiversity loss index (BDI) model in column 1 and in the threatened fish species model in column 2, suggesting that higher levels of financial intermediation is associated with higher biodiversity loss and also threatens the fish species. A potential explanation for this result is that higher levels of financial intermediation, particularly greater credit expansion, stimulates economic activities that lead to biodiversity loss and harms marine habitats. The economic significance of the result is that a one percent increase in the level of financial development is associated with an increase in biodiversity loss by 0.01% and an increase in loss of fish species by 0.394%. The remaining financial determinants, particularly ATM, BC and NP, are statistically insignificant.

Table 4. Financial and macroeconomic determinants of biodiversity loss: full sample analysis using generalized linear model estimation

Variables	The Financial Determinants					The Macroeconomic Determinants					The Financial and Macroeconomic Determinants (full model)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Biodiversity loss index (BDI)	Threatened Fish species (FS)	Threatened plant species (PS)	Threatened mammal species (MS)	Threatened bird species (BS)	Biodiversity loss index (BDI)	Threatened Fish species (FS)	Threatened plant species (PS)	Threatened mammal species (MS)	Threatened bird species (BS)	Biodiversity loss index (BDI)	Threatened Fish species (FS)	Threatened plant species (PS)	Threatened mammal species (MS)	Threatened bird species (BS)
	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)
C	0.273	52.655***	424.36**	28.17**	32.453**	0.209	45.393***	273.61***	49.497*	37.677***	0.358	37.78	528.56**	35.975**	38.152**
	(0.60)	(0.00)	(0.01)	(0.04)	(0.01)	(0.54)	(0.00)	(0.00)	(0.07)	(0.00)	(0.57)	(0.11)	(0.01)	(0.03)	(0.01)
ATM	0.002	0.164	-0.646	-0.074	0.113						0.003	0.216	-0.473	-0.059	0.113
	(0.52)	(0.23)	(0.59)	(0.43)	(0.21)						(0.39)	(0.12)	(0.70)	(0.53)	(0.21)
CB	0.013***	-0.051	-0.363	1.888***	0.422***						0.013***	-0.060	-0.293	1.893***	0.425***
	(0.00)	(0.63)	(0.69)	(0.00)	(0.00)						(0.00)	(0.56)	(0.75)	(0.00)	(0.00)
DP	-0.0006*	-0.007	-0.204*	-0.024***	-0.017**						-0.0008**	-0.022*	-0.233**	-0.028***	-0.017**
	(0.05)	(0.56)	(0.06)	(0.00)	(0.02)						(0.02)	(0.09)	(0.04)	(0.00)	(0.04)
BC	-0.039	-1.984	-9.710	-0.962	-0.491						-0.037	-1.515	-11.115	-0.996	-0.518
	(0.22)	(0.12)	(0.38)	(0.26)	(0.53)						(0.26)	(0.23)	(0.33)	(0.26)	(0.53)
NP	-0.011	0.225	-5.841	0.042	-0.499						-0.009	0.543	-5.672	0.065	-0.533
	(0.54)	(0.76)	(0.35)	(0.93)	(0.26)						(0.64)	(0.45)	(0.38)	(0.89)	(0.25)
DC	0.010*	0.394*	3.079	0.067	0.190						0.012*	0.605***	3.082	0.095	0.193
	(0.07)	(0.07)	(0.11)	(0.66)	(0.17)						(0.05)	(0.00)	(0.14)	(0.56)	(0.20)
GDPR						-0.019	1.184	3.268	-3.797	-1.277	0.008	1.411	4.201	-0.067	-0.619
						(0.55)	(0.48)	(0.82)	(0.32)	(0.31)	(0.86)	(0.39)	(0.78)	(0.95)	(0.56)
INF						-0.019	0.934*	-2.582	-0.712	-0.394	0.017	1.603**	0.974	0.261	0.014
						(0.69)	(0.10)	(0.61)	(0.59)	(0.37)	(0.29)	(0.01)	(0.86)	(0.54)	(0.97)
UNEMP						-0.015	-0.904	-11.952	0.998	0.123	-0.034	-1.060	-13.506*	-1.161*	-0.379
						(0.58)	(0.34)	(0.15)	(0.65)	(0.86)	(0.16)	(0.25)	(0.10)	(0.08)	(0.52)
LR Statistic	38.904	10.24	7.63	11.06	61.33	0.472	4.049	2.419	1.463	1.792	41.966	19.10	10.35	11.15	60.67
Prob (LR)	0.000	0.115	0.267	0.023	0.000	0.924	0.256	0.489	0.691	0.617	0.000	0.024	0.323	0.023	0.000
# countries	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
# obs.	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102

Note. ***, **, * represent statistical significance at the 1%, 5% and 10% levels. Probability value is reported in parenthesis. C = constant term. BDI = biodiversity loss index. FS = threatened fish species indicator. PS = threatened plant species indicator. BS = threatened bird species indicator. MS = indicator of threatened mammal species indicator. ATM = extent of automated teller machine penetration. CB = number of commercial bank branches. DP = number of depositors in a commercial bank. BC = bank capital adequacy ratio. NP = bank nonperforming loan ratio. DC = ratio of domestic private credit by banks to GDP. INF = inflation rate. GDPR = the rate of economic growth. UNEMP = the unemployment rate

4.2. Macroeconomic determinants of biodiversity loss

The INF coefficient is statistically significant in the threatened fish species model, but it is not significant in the biodiversity loss model. This indicates that a high inflation rate is significantly associated with an increase in loss of fish species in emerging market economies. A possible explanation for this result could be that a high inflation rate can decrease people's purchasing power, pushing them to rely more on natural habitats for food, leading to increased fishing in the ocean, thereby threatening and depleting fish species that are vital to human life. This effect is expected to be more pronounced in countries and cities that are closer to the sea and lake. This finding also supports Lawn (2008), who suggest that macroeconomic policy factors such as inflation may exert some influence on achieving biodiversity targets. The UNEMP and GDPR coefficients are statistically insignificant, indicating that unemployment or economic growth rate do not significantly influence biodiversity loss.

4.3. Financial and macroeconomic determinants of biodiversity loss: full sample analysis

In this section, we combined the financial determinants and the macroeconomic determinants in the model. The result is also reported in columns 11-15 in Table 4. The estimation result in the BDI model shows that the CB variable remains positive and significant in the biodiversity loss index (BDI) model in column 1 and in the threatened mammal and bird species models in columns 4 and 5, suggesting that commercial bank branch expansion is associated with higher threatened mammal and bird species which increases biodiversity loss in emerging market economies. As explained previously, this is due to bank branch expansion to new areas which lead to localised habitat destruction and higher carbon emissions from financed bank projects, which threatens both mammal and bird species.

The DP variable is negative and significant in all the biodiversity loss indicators in columns 11 to 15, thereby confirming that higher number of bank depositors is associated with fewer biodiversity loss. A potential explanation for this result is that higher levels of financial inclusion is beneficial for biodiversity.

The DC variable remains positive and significant in the biodiversity loss index (BDI) model in column 1 and in the threatened fish species model in column 2, suggesting that higher levels of financial intermediation is associated with an increase threatened fish species which increases biodiversity loss in emerging market economies. As explained previously, this is likely due to greater credit expansion which stimulates economic activities that lead to biodiversity loss and harms marine habitats. Economic expansion activities may threaten fish and marine habitats by accelerating the rapid development of ocean-front commercial real estate and other business activities, leading to overexploitation and destruction of habitat ecosystem and water pollution that introduce imbalances and threaten ocean biodiversity. The result corroborates the study of Karolyi and Tobin-de la Puente (2023) and Seidl et al (2020) who argue that the financing activities of financial institutions can affect biodiversity resources.

The INF coefficient is also significant in the threatened fish species model, suggesting that a high inflation rate significantly is associated with higher threatened fish species by decreasing people's purchasing power, and pushing them to rely more on natural habitats for food through increased fishing in the ocean which depletes fish species that are vital to human life in emerging market economies. This finding supports Lawn (2008), who suggest that macroeconomic policy factors such as inflation may exert some influence on achieving biodiversity targets. The UNEMP coefficient is negative and statistically significant in columns 13 and 14, suggesting that high unemployment rate is associated with a decrease in biodiversity loss. A potential explanation for this is that high unemployment decreases economic activities that are harmful to biodiversity which leads to few biodiversity loss in emerging market economies. The remaining determinants, particularly ATM, BC, NP and GDPR are statistically insignificant.

4.4. Further analyses

4.4.1. Stepwise analysis of the financial and macro determinants of biodiversity loss

Next, we conduct a stepwise regression analysis to determine whether each explanatory variable has a direct unilateral effect on the biodiversity loss index. First, we conduct a stepwise regression analysis for the effect of the financial determinants on biodiversity loss. The estimation results are reported in columns 1-6 in Table 5. The results show that the CB and NP variables have a significant unilateral positive association with biodiversity loss, suggesting that bank branch expansion and nonperforming loans are associated with increase in biodiversity loss in emerging market economies. The ATM and DC variables are statistically insignificant in the stepwise regression estimation. However, in the full model in column 7, only the CB, DP and DC variables remain significant which confirms the earlier results obtained in section 4.1. We also repeat the same estimation for the macroeconomic variables (i.e. the INF, GDPR and UNEMP variables) in columns 8-10 and the result remains statistically insignificant. Also, in the full model in column 11, the INF, GDPR and UNEMP variables insignificant.

Overall, the results indicate that majority of the financial determinants have a direct standalone effect on biodiversity loss, but this is not the case for the macroeconomic determinants. Rather, the effect of the financial and macroeconomic determinants appear to be significant and more pronounced when they are estimated together in the biodiversity loss model, as shown in column 12 in Table 5.

4.4.2. Interaction analysis

In this section, we conduct an interaction analysis. In the first instance, we interact all the financial inclusion variables (ATM, CB and DP variables) to determine whether collective financial inclusion activities have a joint significant effect on the biodiversity indicators (BDI, FS, PS, MS and BS). The result, reported in columns 1-5 in Table 6, shows that the CB*DP*ATM variable is consistently negative and significant in all the biodiversity loss indicators (BDI, FS, MS and BS) except for the threaten plant species indicator (PS). This result suggest that, with the exception of threatened plant species, higher collective financial inclusion activities have the potential to decrease loss of any threatened animal species (including mammals, bird and fish species). It implies that higher levels of multi-dimensional financial inclusion is beneficial for biodiversity.

Furthermore, we interact the financial intermediation variable, the financial stability variable and the economic growth variable to determine whether greater financial intermediation, bank stability activities and economic expansion contribute to biodiversity loss. The result reported in columns 6-10 in Table 6 shows that the BC*DC*GDPR variable is insignificant in relation to the BDI, PS, FS, MS, and BS dependent variables. This indicates that greater financial intermediation and bank stability activities as well as economic expansion do not have a joint significant effect on biodiversity loss.

4.4.3. Sensitivity to alternative estimations: median quantile regression estimation

Finally, we re-run the entire estimations using the median quantile regression estimation method to ensure that our results are robust to alternative estimation. We use the median quantile regression estimation because (i) it is robust to outliers, (ii) it does not make any assumptions about the distribution, (iii) it models the conditional median and provides a more stable estimate, and (iv) it is a better estimator when dealing with datasets that contain outliers or have a skewed distribution (**see figures 1, 2, 3 and 4 for histogram of dependent variables showing the distribution of the variable**s).

Table 5. Stepwise regression analysis of the financial and macroeconomic determinants of biodiversity loss in emerging markets: full sample generalized linear model estimation

Variables	The Financial Determinants							The macroeconomic Determinants				Combined Determinants
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	BDI	BDI	BDI	BDI	BDI	BDI	BDI	BDI	BDI	BDI	BDI	BDI
	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)
C	-0.068	-0.266*	0.456	0.632	-0.257	-0.187	0.273	0.078	0.018	0.109	0.209	0.358
	(0.76)	(0.06)	(0.14)	(0.11)	(0.16)	(0.48)	(0.60)	(0.75)	(0.93)	(0.66)	(0.54)	(0.57)
ATM	0.001						0.002					0.003
	(0.69)						(0.52)					(0.39)
CB		0.012***					0.013***					0.013***
		(0.00)					(0.00)					(0.00)
DP			-0.0005*				-0.0006*					-0.0008**
			(0.09)				(0.05)					(0.02)
BC				-0.062*			-0.039					-0.037
				(0.08)			(0.22)					(0.26)
NP					0.035**		-0.011					-0.009
					(0.02)		(0.54)					(0.64)
DC						0.005	0.010*					0.012*
						(0.41)	(0.07)					(0.05)
GDPR								-0.019			-0.019	0.008
								(0.69)			(0.55)	(0.86)
INF									-0.002		-0.019	0.017
									(0.88)		(0.69)	(0.29)
UNEMP										-0.015	-0.015	-0.034
										(0.58)	(0.58)	(0.16)
LR Statistic	0.155	29.377	2.866	2.891	5.317	0.686	38.904	0.155	0.020	0.299	0.472	41.966
Prob (LR Statistic)	0.692	0.000	0.090	0.089	0.021	0.407	0.000	0.693	0.887	0.584	0.924	0.000
No. of countries	51	51	51	51	51	51	51	51	51	51	51	51
No. of observation	102	102	102	102	102	102	102	102	102	102	102	102

Note. ***, **, * represent statistical significance at the 1%, 5% and 10% levels. Probability value is reported in parenthesis. C = constant term. BDI = biodiversity loss index. FS = threatened fish species indicator. PS = threatened plant species indicator. BS = threatened bird species indicator. MS = indicator of threatened mammal species indicator. ATM = extent of automated teller machine penetration. CB = number of commercial bank branches. DP = number of depositors in a commercial bank. BC = bank capital adequacy ratio. NP = bank nonperforming loan ratio. DC = ratio of domestic private credit by banks to GDP. INF = inflation rate. GDPR = the rate of economic growth. UNEMP = the unemployment rate.

Table 6. Interaction analysis of the financial and macroeconomic determinants of biodiversity loss in emerging markets: full sample analysis using generalized linear model estimation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variables	Biodiversity loss index (BDI)	Threatened Fish species (FS)	Threatened plant species (PS)	Threatened mammal species (MS)	Threatened bird species (BS)	Biodiversity loss index (BDI)	Threatened Fish species (FS)	Threatened plant species (PS)	Threatened mammal species (MS)	Threatened bird species (BS)
	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)
C	-0.065 (0.92)	-27.844 (0.25)	470.21** (0.03)	16.212 (0.26)	25.401* (0.08)	0.642 (0.51)	39.635 (0.29)	879.745*** (0.00)	42.199* (0.10)	30.325 (0.21)
CB*DP*ATM	-0.0001*** (0.00)	-0.0001* (0.07)	-0.00001 (0.24)	-0.00002*** (0.00)	-0.00002*** (0.00)					
BC*DC*GDPR						0.00008 (0.71)	0.0005 (0.94)	0.101 (0.17)	0.002 (0.75)	-0.002 (0.67)
ATM	0.011** (0.01)	0.411** (0.01)	0.669 (0.67)	0.328*** (0.00)	0.362*** (0.00)	0.003 (0.40)	0.216 (0.12)	-0.473 (0.70)	-0.059 (0.54)	0.113 (0.21)
CB	0.013*** (0.00)	-0.043 (0.68)	-0.193 (0.84)	1.927*** (0.00)	0.447*** (0.00)	0.013*** (0.00)	-0.0604 (0.56)	-0.322 (0.73)	1.892*** (0.00)	0.426*** (0.00)
DP	0.0005 (0.13)	-0.014 (0.28)	-0.191 (0.11)	-0.014* (0.09)	-0.008 (0.32)	-0.0008** (0.02)	-0.022* (0.09)	-0.228* (0.05)	-0.028*** (0.00)	-0.018 (0.45)
BC	-0.035 (0.28)	-1.449 (0.24)	-10.720 (0.35)	-0.862 (0.24)	-0.432 (0.58)	-0.049 (0.29)	-1.595 (0.36)	-26.222* (0.09)	-1.264 (0.30)	-0.181 (0.87)
NP	-0.005 (0.79)	0.638 (0.37)	-5.113 (0.43)	0.254 (0.55)	-0.432 (0.57)	-0.011 (0.58)	0.529 (0.48)	-8.324 (0.22)	0.018 (0.97)	-0.474 (0.33)
DC	0.013** (0.02)	0.636*** (0.00)	3.264 (0.12)	0.157 (0.26)	0.232* (0.10)	0.008 (0.43)	0.528 (0.48)	-1.254 (0.74)	0.018 (0.95)	0.289 (0.29)
GDPR	0.018 (0.67)	1.638 (0.31)	5.537 (0.71)	0.385 (0.69)	-0.327 (0.74)	-0.026 (0.79)	1.191 (0.75)	-37.340 (0.26)	-0.804 (0.75)	0.307 (0.89)
INF	0.021 (0.19)	1.687*** (0.00)	1.467 (0.79)	0.428 (0.25)	0.122 (0.75)	0.016 (0.32)	1.597** (0.01)	-0.021 (0.99)	0.243 (0.57)	0.036 (0.93)
UNEMP	-0.029 (0.20)	-0.960 (0.29)	-12.918 (0.12)	-0.917* (0.09)	-0.252 (0.65)	-0.034 (0.16)	-1.062 (0.25)	-13.875* (0.09)	-1.123* (0.07)	-0.372 (0.53)
LR Statistic	54.467	22.766	11.731	15.73	83.29	41.717	18.891	12.366	11.04	37.209
Prob (LR Statistic)	0.000	0.012	0.303	0.023	0.000	0.000	0.041	0.261	0.123	0.000
No. of countries	51	51	51	51	51	51	51	51	51	51
# observation	102	102	102	102	102	102	102	102	102	102

Note. ***,**,* represent statistical significance at the 1%, 5% and 10% levels. Probability value is reported in parenthesis. C = constant term. BDI = biodiversity loss index. FS = threatened fish species indicator. PS = threatened plant species indicator. BS = threatened bird species indicator. MS = indicator of threatened mammal species indicator. ATM = extent of automated teller machine penetration. CB = number of commercial bank branches. DP = number of depositors in a commercial bank. BC = bank capital adequacy ratio. NP = bank nonperforming loan ratio. DC = ratio of domestic private credit by banks to GDP. INF = inflation rate. GDPR = the rate of economic growth. UNEMP = the unemployment rate.

Table 7. Financial and macroeconomic determinants of biodiversity loss: full sample analysis using median quantile regression estimation

	The Financial and Macroeconomic Determinants (full model)					Interaction analysis					Interaction analysis				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Variables	Biodiversity loss index (BDI)	Threatened Fish species (FS)	Threatened plant species (PS)	Threatened mammals (MS)	Threatened bird species (BS)	Biodiversity loss index (BDI)	Threatened Fish species (FS)	Threatened plant species (PS)	Threatened mammals (MS)	Threatened bird species (BS)	Biodiversity loss index (BDI)	Threatened Fish species (FS)	Threatened plant species (PS)	Threatened mammals (MS)	Threatened bird species (BS)
	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)	Coefficient (P-value)
C	-0.307 (0.64)	15.063 (0.55)	-15.485 (0.66)	12.738 (0.43)	22.039*** (0.00)	0.749 (0.17)	9.842 (0.72)	-21.936 (0.52)	-3.419 (0.80)	23.239*** (0.00)	-0.497 (0.57)	22.298 (0.61)	-15.577 (0.78)	9.845 (0.72)	16.087 (0.21)
CB*DP*ATM						-0.00001* (0.07)	-0.0001 (0.31)	-0.00001 (0.14)	-0.00002*** (0.00)	-0.00001** (0.03)					
BC*DC*GDPR											-0.00003 (0.82)	0.002 (0.82)	-0.004 (0.77)	-0.001 (0.88)	-0.002 (0.38)
ATM	0.002 (0.29)	0.254** (0.02)	0.098 (0.59)	-0.045 (0.65)	-0.016 (0.81)	0.008** (0.04)	0.397** (0.02)	0.361 (0.21)	0.266*** (0.00)	0.119* (0.08)	0.002 (0.29)	0.262** (0.02)	0.081 (0.67)	-0.056 (0.61)	-0.037 (0.77)
CB	0.012*** (0.00)	-0.097 (0.22)	-0.104 (0.59)	1.919*** (0.00)	0.414*** (0.00)	0.013*** (0.00)	-0.038 (0.59)	-0.193 (0.16)	1.936*** (0.00)	0.415*** (0.00)	0.012*** (0.00)	-0.056 (0.43)	-0.105 (0.61)	1.921*** (0.00)	0.412*** (0.00)
DP	-0.0003 (0.29)	-0.029* (0.05)	-0.063** (0.02)	-0.016 (0.29)	-0.011* (0.10)	-0.0003 (0.24)	-0.014 (0.44)	-0.050* (0.06)	-0.010 (0.39)	-0.009* (0.09)	-0.00004 (0.28)	-0.033** (0.04)	-0.063** (0.02)	-0.015 (0.31)	-0.010 (0.14)
BC	-0.030 (0.54)	-0.319 (0.77)	2.031 (0.18)	-0.307 (0.62)	-0.119 (0.73)	-0.014 (0.51)	-0.827 (0.57)	1.857 (0.19)	-0.445 (0.40)	-0.252 (0.46)	-0.019 (0.73)	-0.457 (0.81)	2.387 (0.38)	-0.138 (0.91)	0.212 (0.71)
NP	0.011 (0.32)	1.097* (0.06)	1.187 (0.56)	0.256 (0.52)	-0.328 (0.12)	0.008 (0.46)	1.096* (0.07)	2.287* (0.09)	0.243 (0.51)	-0.385* (0.07)	0.013 (0.29)	1.049 (0.12)	1.184 (0.57)	0.262 (0.56)	-0.203 (0.41)
DC	0.002 (0.82)	0.595* (0.06)	1.899** (0.01)	-0.032 (0.93)	0.062 (0.74)	0.006 (0.44)	0.588* (0.07)	1.717** (0.02)	0.174 (0.59)	-0.129 (0.41)	0.005 (0.67)	0.516 (0.32)	2.005** (0.03)	0.006 (0.98)	0.184 (0.50)
GDPR	0.021 (0.40)	1.757 (0.27)	0.674 (0.76)	-0.300 (0.79)	0.147 (0.78)	0.022 (0.34)	1.537 (0.33)	1.338 (0.53)	0.404 (0.61)	-0.127 (0.81)	0.032 (0.58)	0.569 (0.89)	1.865 (0.73)	-0.062 (0.98)	1.051 (0.36)
INF	0.020 (0.40)	2.104*** (0.00)	2.599*** (0.00)	0.351 (0.30)	0.261 (0.13)	0.017 (0.43)	1.932*** (0.00)	2.586*** (0.00)	0.614** (0.03)	0.357* (0.05)	0.019* (0.07)	2.176*** (0.00)	2.556*** (0.00)	0.354 (0.31)	0.261 (0.17)
UNEMP	-0.027* (0.05)	-1.053 (0.17)	-1.810 (0.12)	-0.481 (0.36)	-0.276 (0.37)	-0.018 (0.21)	-0.886 (0.25)	-1.868 (0.11)	-0.305 (0.46)	-0.285 (0.38)	-0.027* (0.06)	-1.027 (0.20)	-2.097* (0.09)	-0.463 (0.39)	-0.469 (0.16)
Quasi-LR Statistic	30.709	15.259	18.827	12.42	30.487	38.09	18.117	22.455	87.221	43.212	30.177	14.904	18.281	44.289	29.733
Prob (LR Statistic)	0.000	0.084	0.027	0.190	0.000	0.000	0.053	0.013	0.000	0.002	0.000	0.136	0.050	0.000	0.001
No. of countries	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
# observation	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102

Note. ***, **, * represent statistical significance at the 1%, 5% and 10% levels. Probability value is reported in parenthesis. C = constant term. BDI = biodiversity loss index. FS = threatened fish species indicator. PS = threatened plant species indicator. BS = threatened bird species indicator. MS = indicator of threatened mammal species indicator. ATM = extent of automated teller machine penetration. CB = number of commercial bank branches. DP = number of depositors in a commercial bank. BC = bank capital adequacy ratio. NP = bank nonperforming loan ratio. DC = ratio of domestic private credit by banks to GDP. INF = inflation rate. GDPR = the rate of economic growth. UNEMP = the unemployment rate.

In the combined models in columns 1 to 5, the CB, DP, DC and INF variables report coefficient signs and statistical significance that confirm the earlier results obtained in Table 4. In the interaction analysis in Table 7, the CB*DP*ATM variable is consistently negative and significant which confirms the earlier result in columns 6 to 10 in Table 7. This indicates that greater collective financial inclusion activities are associated with decrease in biodiversity loss.

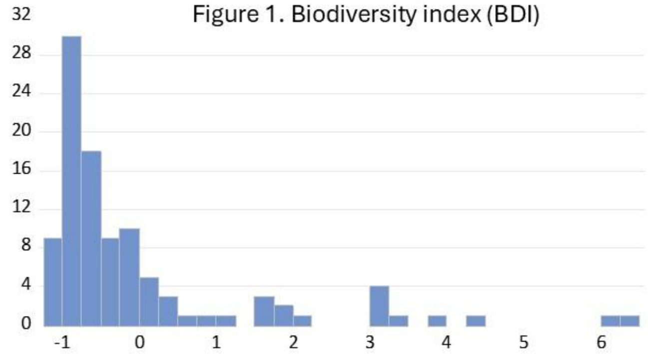

Figure 1. Biodiversity index (BDI)

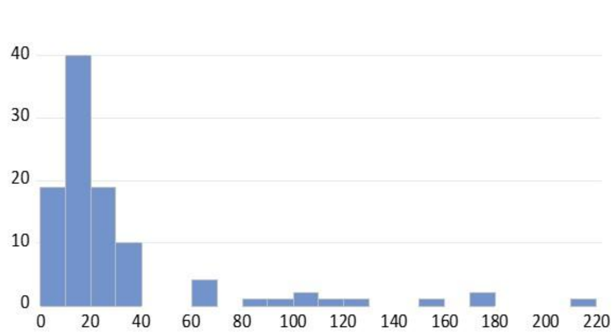

Figure 2. Threatened bird species (BS)

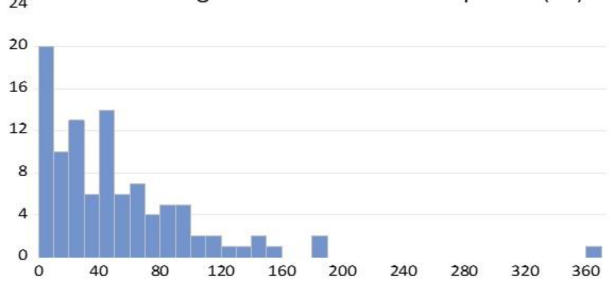

Figure 3. Threatened fish species (FS)

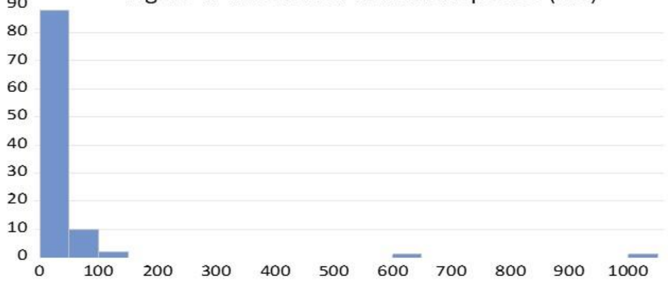

Figure 4. Threatened mammal species (MS)

5. Discussion

5.1 Contribution to the literature

This study advances conceptual understanding of how financial and macroeconomic structures shape biodiversity loss in emerging markets, an area where systematic evidence has remained limited (Akalibey et al., 2023). By jointly examining financial stability, financial inclusion, financial intermediation and macroeconomic conditions across multiple biodiversity indicators, the analysis demonstrates that financial systems are deeply embedded in ecological dynamics. They influence patterns of land use, production expansion and natural resource extraction that ultimately affect ecosystem resilience (Leach et al., 2021).

A first contribution is the challenge it poses to the implicit assumption that financial stability naturally supports environmental sustainability. Traditional perspectives often view stable and well capitalised banking systems as promoting long-term development. However, the findings indicate that high capital adequacy and low nonperforming loan ratios may not significantly influence or decrease biodiversity loss. This insight advances the emerging concept of a finance-biodiversity paradox, where financially sound systems continue to channel resources toward activities that intensify ecological pressure (Antal and Van den Bergh, 2013; Nedopil, 2023). The results highlight the need to reevaluate the ecological implications of prudential indicators that are usually interpreted as positive signs of financial system health.

A second contribution concerns the conceptual framing of financial inclusion. The literature often presents financial inclusion as a catalyst for equitable development, yet its environmental implications remain understudied. The findings suggests that financial inclusion is not inherently benign from an ecological perspective. Its effects depend critically on the types of activities that expanded financial access enables in emerging markets. When bank branch expansion intensify land use or land conversion, biodiversity pressures increase. When inclusion is directed toward environmentally responsible livelihoods, the opposite may occur. This duality strengthens emerging theories of inclusive green finance by framing financial inclusion as a context dependent mechanism whose ecological effects depend on regulatory quality, credit allocation and institutional capacity (Qamruzzaman, 2025; Navin et al., 2025).

A third contribution relates to macroeconomic stability. Variables such as inflation, unemployment and output growth are typically conceptualised within frameworks focused on stabilisation, poverty reduction or growth acceleration. They are not traditionally examined as determinants of biodiversity loss in prior literature. The results show that stabilisation policies (e.g. high employment or low unemployment) can influence the pace and structure of economic expansion, which can accelerate land conversion and resource exploitation. This provides empirical support for ecological macroeconomic theories calling for the integration of biodiversity considerations into macroeconomic modelling and policy design (Hardt and O'Neill, 2017; Rezai and Stagl, 2016). It also highlights that macroeconomic conditions cannot be analytically separated from ecological outcomes in rapidly developing economies.

Taken together, these contributions advance an interdisciplinary perspective that positions financial development, financial stability and macroeconomic management as structural drivers of biodiversity dynamics in emerging markets. They underscore the need for conceptual frameworks or theories of financial systems and macroeconomic policy to more explicitly integrate nature related risks and biodiversity dependencies.

5.2 Practical implications

The findings of this study generate several practical implications for managers, financial institutions and policymakers operating in emerging market contexts. These implications concern both the design of financial practices and the broader governance of financial systems in environments characterised by rapid economic expansion and high ecological vulnerability.

A first implication relates to the internal decision making processes of financial institutions. Credit allocation, risk assessment and financial product design influence patterns of investment and land use and may therefore generate unintended ecological consequences. Managers should incorporate biodiversity considerations into lending criteria, especially when financing sectors with significant environmental footprints. Strengthening environmental due diligence, adopting biodiversity sensitive risk metrics and integrating nature related risk into credit assessments can reduce the ecological impact associated with financial operations.

A second implication concerns the development of financial inclusion strategies. The expansion of financial access should not occur in isolation from environmental objectives. Managers responsible for inclusive finance initiatives should ensure that new financial services do not inadvertently support activities that degrade ecosystems. Basic environmental screening mechanisms, sustainability-oriented credit lines and incentives for clients to adopt environmentally responsible practices can mitigate biodiversity pressures while preserving the developmental benefits of financial inclusion.

A third implication involves the interaction between organisational strategies and macroeconomic conditions. Periods of low inflation, high employment and strong growth often stimulate investment and production, which can accelerate land conversion and habitat loss. Managers in both private and public institutions should therefore recognise the ecological implications of decisions taken during economically favourable conditions. Incorporating nature related risks into strategic planning and investment decisions can align growth oriented strategies with long term ecological resilience.

A final implication concerns the strategic role of the banking sector in biodiversity conservation. Banks are well positioned to influence the allocation of capital toward activities with lower ecological impacts. Responsible lending frameworks, enhanced due diligence procedures and the development of financial instruments that support conservation or sustainable production can position the banking sector as an active contributor to biodiversity protection. By reducing nature related risks in their portfolios, financial institutions may also strengthen their own long term financial stability.

5.3. Limitations

The study faces several limitations. The analysis is constrained by the short time period covered by biodiversity data currently available in the World Bank database, which limits the ability to observe long term trends. Future research would benefit from longer time series that allow for a more detailed assessment of how financial and economic conditions affect biodiversity over time. In addition, the biodiversity indicators used provide only a partial view of ecosystem health. Incorporating more detailed ecological measures, such as land use changes or habitat conditions, would offer a more complete picture of the mechanisms behind biodiversity decline.

6. Conclusion

This study examined how financial and macroeconomic determinants of biodiversity loss in emerging market economies. By analysing multiple indicators of biodiversity decline together with financial determinants (which include measures of financial stability, financial inclusion, and financial intermediation) and macroeconomic determinants, the findings show that these systems are closely connected. Bank branch expansion and higher level of financial intermediation, via higher private sector credit, appear to coincide with higher biodiversity loss while financial inclusion via increased number of bank depositors decreases biodiversity loss. Capital adequacy ratio does not affect biodiversity loss. High inflation increases biodiversity loss.

The findings indicate that biodiversity considerations should be incorporated into financial regulation, credit allocation processes, and macroeconomic policymaking. In contexts where ecosystems are already under pressure, financial institutions and public authorities need to be aware that decisions aimed at strengthening financial stability or expanding access to finance may have unintended ecological consequences. A clearer understanding of these interactions can help support policies that promote financial inclusion and economic development without increasing biodiversity loss. Overall, the study highlights the relevance of financial and economic factors in understanding biodiversity loss in emerging markets. A better integration of ecological considerations into financial and economic decision making can support more effective strategies for conserving biodiversity while maintaining economic stability.

Further research could extend the analysis to additional regions, particularly areas where biodiversity pressure is high and economic development is uneven. It would also be useful to examine sector specific financial channels, such as agricultural credit or lending to extractive industries, to identify the activities through which financial decisions most directly affect biodiversity. Complementary qualitative analyses could help clarify how regulatory frameworks, institutional capacity, and local practices shape the relationship between financial systems and biodiversity. Finally, future studies can revisit our research topic and incorporate additional country-level control variables such as land area, population, GDP per capita, forest area, protected areas, agricultural land, or environmental governance indicators to determine how these factors affect biodiversity loss.

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data curation: P.K.O.; writing—original draft preparation: N.D.S. and L.G.; writing—review and editing: N.D.S.; visualization: P.K.O.; supervision: P.K.O.; project administration: P.K.O.

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Data Availability Statement: All data used for this research are accessible in the World Bank's 'World Development Indicator' and 'Global Financial Development' databases available at: https://databank.worldbank.org/.

Conflicts of Interest: The authors declare no conflict of interest.

AI Use Statement: Grammarly software was used for grammatical editing after post-acceptance. No AI tools were used in the preparation of this research article.

Appendix

Table A1. Variance Inflation Factors

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.396415	23.89371	NA
ATM	1.31E-05	3.424160	1.457954
CB	7.51E-06	1.721823	1.509788
DP	1.17E-07	8.029212	1.825798
BC	0.001123	8.124865	1.099097
NP	0.000355	2.953684	1.858780
DC	3.82E-05	5.608277	1.688936
GDPR	0.001866	2.934760	1.056664
INF	0.000272	2.254056	1.289543
UNEMP	0.000588	2.915227	1.034006

References

Akalibey, S., Ahenkan, A., Duho, K. C. T., Maloreh-Nyamekye, T., & Schneider, J. (2023). Drivers of green economy in an emerging market: Generic and sector-specific insights. *Journal of Cleaner Production*, 425, 138857. https://doi.org/10.1016/j.jclepro.2023.138857

Ali, M., Rahman, M., & Chowdhury, M. T. (2024). Financial development, financial inclusion, and environmental sustainability in Sub-Saharan Africa. *Environmental Science and Pollution Research*, 31(2), 2089-2105. https://doi.org/10.1007/s11356-023-28410-2

Antal, M., & Van den Bergh, J. C. (2013). Macroeconomics, financial crisis and the environment: Strategies for a sustainability transition. *Environmental Innovation and Societal Transitions*, 6, 47-66. https://doi.org/10.1016/j.eist.2013.01.002

Becker, A., Di Girolamo, F. E., & Rho, C. (2025). Loan pricing and biodiversity exposure: Nature-related spillovers to the financial sector. *Research in International Business and Finance*, 75, 102724. https://doi.org/10.1016/j.ribaf.2024.102724

Busch, T., Bassen, A., Lopatta, K., Knob, L., & Remer, S. (2024). Biodiversity and financial risk assessments. *Wissenschaftsplattform Sustainable Finance, Policy Brief, No 5.**

Calice, P. (2023). Biodiversity and finance: A preliminary assessment of banking systems' exposure to nature loss in emerging markets. World Bank Policy Research Working Paper No. 10432. https://doi.org/10.1596/1813-9450-10432

Cosma, S., Rimo, G., & Cosma, S. (2023). Conservation finance: What are we not doing? A review and research agenda. *Journal of Environmental Management*, 336, 117649. https://doi.org/10.1016/j.jenvman.2023.117649

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P., & van den Belt, M. (1997). The value of the world's ecosystem services and natural capital. *Nature*, 387(6630), 253-260. https://doi.org/10.1038/387253a0

Daily, G. C. (2000). Management objectives for the protection of ecosystem services. *Environmental Science & Policy*, 3(6), 333-339. https://doi.org/10.1016/S1462-9011(00)00102-7

Deutz, A., Heal, G. M., Niu, R., Swanson, E., Townshend, T., Li, Z., Delmar, A., Meghji, A., Sethi, S. A., Tobin-de la Puente, J. (2020). Financing nature: Closing the global biodiversity financing gap. https://www.paulsoninstitute.org/wp-content/uploads/2020/10/FINANCING-NATURE_Full-Report_Final-with-endorsements_101420.pdf

Ehigiamusoe, K. U., & Samsurijan, M. S. (2021). What matters for finance-growth nexus? A critical survey of macroeconomic stability, institutions, financial and economic development. *International Journal of Finance & Economics*, 26(4), 5302-5320. https://doi.org/10.1002/ijfe.2066

Farber, S. C., Costanza, R., & Wilson, M. A. (2002). Economic and ecological concepts for valuing ecosystem services. *Ecological Eeconomics*, 41(3), 375-392. https://doi.org/10.1016/S0921-8009(02)00088-5
Flammer, C., Giroux, T., & Heal, G. M. (2025). Biodiversity finance. *Journal of Financial Economics*, 154, 103987. https://doi.org/10.1016/j.jfineco.2024.103987
Garel, A., Romec, A., Sautner, Z., & Wagner, A. F. (2024). Do investors care about biodiversity? *Review of Finance*, 28(4), 1151-1186. https://doi.org/10.1093/rof/rfae010
Giglio, S., Kuchler, T., Stroebel, J., & Wang, O. (2024). The economics of biodiversity loss (No. w32678). National Bureau of Economic Research. https://doi.org/10.3386/w32678
Giraldo, C., Giraldo, I., Gomez-Gonzalez, J. E., & Uribe, J. M. (2024). Financial integration and banking stability: A post-global crisis assessment. *Economic Modelling*, 139, 106835. https://doi.org/10.1016/j.econmod.2024.106835
Hardt, L., & O'Neill, D. W. (2017). Ecological macroeconomic models: assessing current developments. *Ecological Economics*, 134, 198-211. https://doi.org/10.1016/j.ecolecon.2016.12.027
Ho, K., & Wong, A. (2023). Effect of climate-related risk on the costs of bank loans: Evidence from syndicated loan markets in emerging economies. *Emerging Markets Review*, 55, 100977. https://doi.org/10.1016/j.ememar.2022.100977
https://doi.org/10.1111/j.1523-1739.2008.01092.x
Hudson, R. (2024). Biodiversity and risk in the financial sector. *Journal of Sustainable Finance and Accounting*, 2, 100009. https://doi.org/10.1016/j.josfa.2024.100009
Hutchinson, M. C., & Lucey, B. (2024). A bibliometric and systemic literature review of biodiversity finance. *Finance Research Letters*, 64, 105377. https://doi.org/10.1016/j.frl.2024.105377
International Monetary Fund (IMF). (2024). Nature-related economic and financial risks and policy responses. IMF Staff Discussion Note SDN/2024/002.
Joof, F., Samour, A., Tursoy, T., Ali, M. (2023). Climate change, insurance market, renewable energy, and biodiversity: double materiality concept from BRICS countries. *Environmental Science and Pollution Research*, 30, 28676-28689. https://doi.org/10.1007/s11356-022-24068-4
Karolyi, G. A., & Tobin-de la Puente, J. (2023). Biodiversity finance: A call for research into financing nature. *Financial Management*, 52(2), 231-251. https://doi.org/10.1111/fima.12417
Khan, I., & Sahu, M. (2025). Enhancing financial inclusion in India: the impact of socioeconomic and macroeconomic factors. *Journal of Financial Economic Policy*, 17(2), 270-294. https://doi.org/10.1108/JFEP-04-2024-0105
Lawn, P. (2008). Macroeconomic policy, growth, and biodiversity conservation. *Conservation Biology*, 22(6), 1418-1423.
Leach, M., MacGregor, H., Scoones, I., & Wilkinson, A. (2021). Post-pandemic transformations: How and why COVID-19 requires us to rethink development. *World Development*, 138, 105233. https://doi.org/10.1016/j.worlddev.2020.105233
Li, H., Abbas, Q., Ramzan, M., & Fatima, S. (2024). Impact of Domestic Investment on Domestic Credit Level. Does Institutional Quality Matter?. *Journal of the Knowledge Economy*, 1-34. https://doi.org/10.1007/s13132-024-02466-y
Naffa, H. (2025). Nature-Inspired Finance for Biodiversity Protection. In *Biodiversity Finance: The Economic, Operational, and Societal Impacts of Biodiversity Loss* (pp. 33-57). Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-032-02029-1_3
Navin, Y., Ayyagari, L. R., & Rajan, A. (2025). Balancing growth and green goals: financial access, entrepreneurship, and sustainable development in the BRICS economies. *Discover Sustainability*, 6(1), 708. https://doi.org/10.1007/s43621-025-01625-8
Nedopil, C. (2023). Integrating biodiversity into financial decision-making: Challenges and four principles. *Business Strategy and the Environment*, 32(4), 1619-1633. https://doi.org/10.1002/bse.3208
NGFS (2026). Note on the supervision of nature-related financial risks. Network for Greening the Financial System (NGFS) Report, April 2026.
Nguyen Thi Truc, A., & Le Thanh, H. (2025). Do the climate-related financial policies enhance bank stability? The role of central bank. *Journal of Sustainable Finance & Investment*, 1-24. https://doi.org/10.1080/20430795.2025.2559237
OECD. (2023). Assessing biodiversity-related financial risks. OECD Report.
O'Neill, J. (2021). Is the emerging world still emerging?. *Finance & Development*, 10-11.
Ozili, P. K. (2024). Financial inclusion and financial crisis: arguments, stylized facts and evidence. *Economic Notes*, 53(3), e12245. https://doi.org/10.1111/ecno.12245
Ozili, P. K. (2025). Carbon emissions, financial stability and bank profitability in non-crisis years. *Development and Sustainability in Economics and Finance*, 100079. https://doi.org/10.1016/j.dsef.2025.100079
Qamruzzaman, M. (2025). The effects of natural resources, education, and financial inclusion in achieving environmental sustainability in resources-abundance nations. *Discover Sustainability*, 6(1), 136. https://doi.org/10.1007/s43621-025-00853-2
Rezai, A., & Stagl, S. (2016). Ecological macroeconomics: Introduction and review. *Ecological Economics*, 121, 181-185. https://doi.org/10.1016/j.ecolecon.2015.12.003
Roncaglia de Carvalho, A., Ribeiro, R. S., & Marques, A. M. (2018). Economic development and inflation: a theoretical and empirical analysis. *International Review of Applied Economics*, 32(4), 546-565. https://doi.org/10.1080/02692171.2017.1351531
Schoneveld, G., & Zoomers, A. (2015). Natural resource privatisation in Sub-Saharan Africa and the challenges for inclusive green growth. *International Development Planning Review*, 37(1), 95-118. https://doi.org/10.3828/idpr.2015.10
Schrapffer, A., Riano Sanchez, J. A., & Bres, J. (2024). Double materiality of biodiversity-related risks: From direct to supply chain portfolio assessment. Sustainability *Accounting, Management and Policy Journal*, 15(3), 567-589. https://doi.org/10.2139/ssrn.4984305

Seidl, A., Mulungu, K., Arlaud, M., van den Heuvel, O., & Riva, M. (2020). Finance for nature: A global estimate of public biodiversity investments. *Ecosystem Services*, 46, 101216. https://doi.org/10.1016/j.ecoser.2020.101216

Sun, W., Mei, J., Chen, K., & Li, Z. (2025). Biodiversity risk and value creation in emerging markets. *Finance Research Letters*, 108069. https://doi.org/10.1016/j.frl.2025.108069

Thompson, R., & Baker, R. J. (1981). Composite link functions in generalized linear models. *Journal of the Royal Statistical Society: Series C (Applied Statistics)*, 30(2), 125-131. https://doi.org/10.2307/2346381

Turner, R. K., & Daily, G. C. (2008). The ecosystem services framework and natural capital conservation. *Environmental and resource economics*, 39(1), 25-35. https://doi.org/10.1007/s10640-007-9176-6

Xing, L., & Wang, S. (2025). Can industrial agglomeration affect biodiversity loss?. *Energy & Environment*, 36(4), 1824-1848. https://doi.org/10.1177/0958305X231200575

Zhang, S., Zhou, Y., Yu, R., Xu, X., Xu, M., Li, G., ... & Yang, Y. (2022). China's biodiversity conservation in the process of implementing the sustainable development goals (SDGs). *Journal of Cleaner Production*, 338, 130595. https://doi.org/10.1016/j.jclepro.2022.130595

Zu Ermgassen, S. O., Hawkins, I., Lundhede, T., Liu, Q., Thorsen, B. J., & Bull, J. W. (2025). The current state, opportunities and challenges for upscaling private investment in biodiversity in Europe. *Nature Ecology & Evolution*, 9(2), 115-128. https://doi.org/10.1038/s41559-024-02632-0