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Banks and nature: How strongly does the banking sector in Germany depend on ecosystem services?

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Non-technical Summary

Research Question

This study investigates to which extent the banking sector in Germany depends on ecosystem services. Ecosystem services are derived from nature's capacity to provide inputs for economic activity, such as clean water and fertile soils. Understanding these dependencies is crucial, since the degradation of ecosystem services can have significant economic and financial implications.

Contribution

We analyze the extent to which banks in Germany as a whole and as separate categories of banks are dependent on ecosystem services through their corporate lending. By examining both direct and indirect dependencies, we aim to shed light on those ecosystem services most critical to banks, and how dependencies vary among various categories of banks. Our analysis is based on a combination of datasets and methodologies, illustrating how dependencies on different ecosystem services vary, and that banks are not affected equally.

Results

Our findings reveal that through their corporate loan portfolios, banks in Germany are highly dependent on ecosystem services, particularly on several services related to water. Most significant for banks' corporate lending are services preventing soil erosion as well as those mitigating storm damage. Distinctively, while direct dependencies are important, we find that indirect dependencies – those arising from supply chain connections – are in many cases even more pronounced. In addition, regionally focused banks show stronger dependencies on ecosystem services compared to other categories of banks. Overall, our study underscores the importance of further analyzing nature-related risks and their implications for banks.

Nichttechnische Zusammenfassung

Fragestellung

Diese Studie untersucht, inwieweit der Bankensektor in Deutschland von Ökosystemleistungen abhängig ist. Ökosystemleistungen basieren auf der Fähigkeit der Natur, Inputfaktoren für ökonomische Aktivitäten bereitzustellen, wie etwa sauberes Wasser und fruchtbare Böden. Das Verständnis dieser Abhängigkeiten ist entscheidend, da eine Schädigung von Ökosystemleistungen bedeutende wirtschaftliche und finanzielle Auswirkungen haben kann.

Beitrag

Wir analysieren, inwieweit Banken in Deutschland insgesamt und einzelne Bankengruppen durch ihre Unternehmenskreditvergabe von Ökosystemleistungen abhängig sind. Durch die Untersuchung sowohl direkter als auch indirekter Abhängigkeiten wollen wir aufzeigen, welche Ökosystemleistungen für Banken am kritischsten sind und wie sich diese Abhängigkeiten zwischen verschiedenen Bankengruppen unterscheiden. Unsere Analyse stützt sich auf eine Kombination von Datensätzen und Methoden, um zu veranschaulichen, wie die Abhängigkeit von verschiedenen Ökosystemleistungen zwischen Banken variiert.

Ergebnisse

Unsere Ergebnisse zeigen, dass Banken in Deutschland durch ihre Unternehmenskreditvergabe stark auf Ökosystemleistungen angewiesen sind, besonders auf eine Reihe solcher, die sich auf Wasser beziehen. Am bedeutendsten für die Unternehmensfinanzierung durch Banken sind Ökosystemleistungen, die Bodenerosion verhindern und Sturmschäden mindern. Bezeichnend ist, dass indirekte Abhängigkeiten – jene, die sich aus Lieferkettenverbindungen ergeben – in vielen Fällen noch ausgeprägter sind als direkte Abhängigkeiten. Außerdem weisen regional tätige Banken stärkere Abhängigkeiten von Ökosystemleistungen auf als andere Bankengruppen. Insgesamt unterstreicht unsere Studie die Bedeutung weiterer Analysen von naturbezogenen Risiken und deren Auswirkungen auf Banken.

Banks and Nature: How strongly does the banking sector in Germany depend on ecosystem services?

Annette Becker*, Marvin Dransfeld*, Fabian Genswein*, Emily Kormanyos*, Paolo Krischak*, Carina Schlam*, Julia Thomas†

Abstract: This study examines the dependency of the banking sector in Germany on ecosystem services through its corporate lending. Ecosystem services are derived from nature's capacity to provide inputs for economic activity. We analyze how banks overall and categories of banks in Germany depend on ecosystem services, both directly and indirectly. Our findings indicate that banks are particularly reliant on a number of ecosystem services that relate either to water resources, or to water-regulating aspects. Additionally, indirect dependencies from supply chain connections frequently outweigh direct ones, and regionally focused banks show higher dependencies on ecosystem services compared to other categories of banks. These results underscore the importance of a better comprehension of nature-related risks and their implications for banks.

Keywords: Banks, Biodiversity, Corporate loans, Dependency on ecosystem services, Germany, Nature-related risk, Supply chains, Water
JEL-Classification: C67, G21, G38, Q25, Q57

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1 Introduction

Biodiversity, consisting of the variety of species, genetics, and ecosystems, is an essential prerequisite for sustainable and long-term economic activity. The loss of biodiversity[1], as well as environmental degradation more broadly – both also due to climate change – impairs nature's capacity to provide input factors for economic activities (so-called ecosystem services). If certain ecosystem services are no longer available or only available to a limited extent in the future, economic and financial risks may arise (NGFS, 2023). Such nature-related risks can manifest in loan portfolios of banks, thereby impacting the stability of the banking sector. Accordingly, it may be prudent for banks to incorporate the role of ecosystem services into their risk assessment and strategic planning. For Germany, with its numerous regionally focused banks, such an analysis is particularly relevant, as the dependencies on ecosystem services – and thus the corresponding nature-related risks – can vary significantly at the local level.

This study analyzes the dependency of banks in Germany on ecosystem services through their corporate lending.[2] In this pursuit, it takes an initial step in understanding financial risks resulting from the destruction of natural resources by, among other things, seeking answers to the following questions: How strongly does the banking sector in Germany depend on ecosystem services? How do these dependencies differ between categories of banks? Which ecosystem services are particularly relevant and how important are dependencies originating from supply chains? We distinguish between two types of dependencies: direct and indirect dependencies. A direct dependency of a bank refers to the immediate reliance of a corporate borrower of the same bank on one or more ecosystem services, but not the dependency on ecosystem services by the bank's operations itself. An indirect dependency arises from the interconnectedness of various economic sectors through supply chains.

In this paper, we review the relevant literature, detail our data sources, outline our methodology, and present our findings. Importantly, we place particular emphasis on the methodological approach and provide detailed descriptions of the results. We begin with an in-depth literature review to contextualize our research within existing studies in Section 2. In

[1] The loss of biodiversity is driven, among other factors, by extractive industries such as agriculture, intensive livestock farming, forestry, fishing, aquaculture, mining, and petrochemicals. The main drivers include land and sea use change, direct overexploitation, climate change, environmental pollution, and invasive species (IPBES, 2019).

[2] Some outcomes of this investigation were already published in the Bundesbank's Monthly Report edition from April 2026.

Section 3, we outline the datasets utilized for our analysis and present our methodology for calculating dependency scores, distinguishing between direct and indirect dependencies. Additionally, we explain how we weight the dependency scores with the individual bank's corporate loan portfolios. The results of our analysis are presented in Section 4, followed by a conclusion in Section 5 that synthesizes our findings and their implications for understanding financial risks associated with the degradation of nature.

2 Literature review

In light of the rising awareness that biodiversity loss and nature degradation can pose significant economic and financial risks, research during recent years has widened its focus to encompass the financial sector's dependencies on ecosystem services. Nevertheless, substantial gaps persist in our comprehension of nature-related financial risks, including, for instance, their interconnections with climate change (e.g., IPCC, 2022; Sánchez-García et al., 2025). In the following, we outline the main research results, with a particular focus on the banking sector.

A growing body of empirical research demonstrates that banks are significantly exposed to nature-related risks through their loan and investment portfolios, which can be further intensified by interacting climate hazards. Boldrini et al. (2023) show that 75% of all corporate loan exposures in the euro area have a strong dependency on at least one ecosystem service, with greater vulnerabilities concentrated in certain regions and economic sectors. Expanding upon this perspective, Ceglar et al. (2025b) refine that a small number of banks, through their lending to companies, account for the majority of the euro area banking system's biodiversity footprint. They also emphasize that nature-related risks can be exacerbated by climate change. For instance, their study reveals that almost 60% of loans in the euro area are exposed to companies facing unmet flood protection needs. This illustrates how the interplay of various ecosystem and climate hazards can amplify financial risks. Examinations of national banking systems, including those for France (Svartzman et al., 2021; Hadji-Lazaro et al., 2024) and the Netherlands (Van Toor et al., 2020), confirm at the country level that banks' financial assets are significantly exposed to nature-related risks, consistent with the findings for the euro area as a whole. Liaqat et al. (2025) present evidence from China, displaying that biodiversity risk increases the share of non-performing loans and reduces bank performance, especially for

smaller and less diversified banks.

Recent methodological advances have significantly improved the competency to assess and quantify the financial sector's exposure to the economic reliance and pressures on nature, transitioning from input-output models to risk-based frameworks. The integration of environmental and ecosystem service considerations into economic and financial analysis is rooted in the extension of input-output models (Leontief, 1970; Stadler et al., 2018). Environmentally extended multi-regional input-output tables, such as those provided by EXIOBASE, form the backbone for quantifying indirect dependencies of economic sectors on ecosystem services, facilitating the tracking of risk transmission through supply chains (Stadler et al., 2018). Latest conceptual advances have centered on developing frameworks that explicitly link ecosystem service degradation to financial risk. Gallet et al. (2024) introduce the 'Ecosystem Service Degradation Sensitivity Indicator' (EDSI), which is designed to quantify the sensitivity of banks' capital buffers to shocks in ecosystem services. Ceglar et al. (2025a) apply the nature value-at-risk (NVaR) framework which offers a structured methodology for quantifying potential economic output at risk from ecosystem degradation. Not only do they find water-related risks to be the most material ones for the euro area economy; moreover, water-related risks contribute as the dominant transmission channel to banks' portfolios. Thus, both studies move beyond an exposure analysis to a more risk-based approach.

Nature-related risks are progressively priced in financial markets, raising costs for firms or countries most dependent or impactful on the environment. Becker et al. (2025) observe that exposure to biodiversity loss is being more frequently factored into syndicated loan contracts, with higher loan spreads for borrowers with production sites located close to fragile ecosystems. Garel et al. (2026) develop firm-level measures of dependency on ecosystem services, demonstrating that high nature dependency predicts downside risk, and nature-related incidents in turn arise when high nature dependency leads firms to damage nature, overuse resources, or trigger disputes with local communities. Furthermore, market-based research shows that nature-related risks are increasingly reflected in asset prices. Giglio et al. (2024) reveal that news about biodiversity loss lead to wider spreads on credit default swaps, with the effect being more pronounced in countries with more depleted ecosystems.

Despite the growing recognition of nature-related risks, both the disclosure of such risks and their integration into banks' risk management practices remain limited and frag-

mented. Empirical evidence illustrates that banks have been slow in the systematic evaluation and uptake of their dependencies on ecosystem services and related risks into their operations and performance (Mundaca and Heintze, 2024). Raimo et al. (2026) conduct a manual content analysis of the official websites of European banks using a dedicated biodiversity disclosure index and document that biodiversity-related information is only sparsely disclosed, suggesting that biodiversity remains a marginal aspect of banks' sustainability communication strategies. Moreover, an additional econometric analysis indicates that bank size, internationalization, and online visibility are positively associated with the extent of biodiversity disclosure, whereas bank age does not contribute significantly.

The literature increasingly recognizes the propagation of nature-related risks to the financial system, however, granular analyses for countries with banking sectors of high complexity such as Germany have not been produced yet. While significant progress has been achieved in developing conceptual frameworks and empirical evidence, most existing studies focus either on the euro area in its entirety, or on jurisdictions with relatively homogenous banking sectors. In contrast, Germany's banking system stands out for its distinctive three-pillar structure – private, public, and cooperative banks – which exhibit significant differences in business model, regional focus, and risk profile. To date, there is a lack of systematic, pillar-specific analyses of ecosystem service dependencies within this diverse landscape. Our study addresses this gap through an explicit differentiation between the main categories of banks. By drawing upon the most recent ENCORE database (2024 edition), we shed new light on how the exposure to nature-related risks is distributed within a structurally complex domestic banking system.

3 Data and methodology

3.1 Data sources

This analysis leverages the databases ENCORE, EXIOBASE, and AnaCredit to evaluate ecosystem service dependencies of banks in Germany. ENCORE (Natural Capital Finance Alliance, 2022) grants access to a systematic framework for assessing the relevance of ecosystem services to economic activities through direct dependency scores. Building on the ENCORE

framework, we identify indirect dependencies using EXIOBASE (Stadler et al., 2018). Lastly, AnaCredit[3] allows for the mapping of these dependencies to the corporate loan portfolios of individual banks in Germany, facilitating an understanding of the financial exposure to ecosystem services. We present the data sources in detail below.

ENCORE systematically evaluates ecosystem service dependencies by assigning materiality scores that reflect their significance to economic activities. These materiality scores are categorized by economic sectors. In doing so, ENCORE provides a structured way to obtain the dependencies of economic sectors on specific ecosystem services, which forms the basis for our sectoral analysis in Section 3.2. The approach has been developed by the Natural Capital Finance Alliance (NCFA) in collaboration with the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), and receives periodical upgrades. In its version from July 2024, ENCORE links 271 economic sectors to 25 ecosystem services.[4] For each combination of ecosystem service and economic sector, ENCORE assigns a dependency score on a five-point scale, ranging from 'very low' to 'very high'. These scores are primarily derived from an extensive literature review, with additional consultations from field domain specialists, and are validated by industry experts, ensuring a robust foundation for the assessment. For a number of ecosystem services, the materiality ratings have been quantitatively determined, and enhanced with additional qualitative information.[5] The ratings single out two critical aspects: (i) the significance of the loss in functionality of a disrupted ecosystem service for the economic sector, and (ii) the degree of financial cost to the economic sector for adapting to the disruption of the ecosystem service. Consequently, a high materiality score signifies that the obstruction of the ecosystem service could hinder economic activity across dependent sectors, thereby putting sectoral operation and output at risk.

ENCORE has several limitations, as it does neither account for geographical differences nor does the current version accurately display indirect dependencies through supply chains. Specifically, ENCORE does not consider spatial disparities: Irrespective of location and associated climate zone, the dependency of a given economic sector on an ecosystem service has the same value. Furthermore, ENCORE makes only direct dependency scores

[3] See Analytical Credit Datasets – German Part | Deutsche Bundesbank.

[4] See the list of ecosystem services in ENCORE (2026a).

[5] Biomass provisioning services, water supply, soil quality regulation, water flow regulation and pollination services are based on quantitative indicators that enabled assessing the extent to which their functionality loss would affect the dependent economic sectors.

available in the most up-to-date version. As a novelty, it contains key upstream and downstream value chain linkages. However, these are neither exhaustively covering up- and downstream connections between economic sectors, nor do they report materiality ratings. For this reason, ENCORE offers a first-order approximation of direct ecosystem service dependencies. Additionally, ENCORE classifies dependencies into discrete scores without clarifying whether the intervals between materiality classes are linear. Despite these constraining factors, ENCORE's methodology has gained widespread acceptance in the literature. To broaden its analytical capacity, it is commonly combined with input-output tables to accommodate supply-chain effects (e.g., Svartzman et al., 2021; World Bank and Bank Negara Malaysia, 2022; Boldrini et al., 2023; Ceglar et al., 2025b).

To enhance our analysis of direct dependencies, we draw from the EXIOBASE database, which facilitates the identification of indirect dependencies across economic sectors. EXIOBASE is an environmentally extended multi-regional input-output table that covers 44 countries, five Rest-of-World regions, and 163 industries. It provides datasets that capture inter-industrial relationships that show both country-specific and cross-country variations, permitting an in-depth, multi-regional analysis of supply chain linkages.[6] This study relies on the dataset from EXIOBASE version 3.9.6 for the year 2022.

Finally, we employ AnaCredit by mapping ecosystem services through their dependent economic sector to banks' corporate loan portfolios in order to capture the strength of the relationship between ecosystem services and corporate lending. This approach assigns each bank in Germany in our sample a total direct and indirect dependency score based on its ecosystem service dependencies. AnaCredit is a comprehensive database that collects detailed and harmonized information on individual loans extended by banks in the euro area. Our focus in this study lies on banks active in Germany. It entails data on individual loans, such as the amount, maturity, and collateral, as well as borrower characteristics, enabling a granular analysis of banks' credit risk. Banks resident in Germany, as well as branches that are located in Germany but belong to banks based abroad, are required to report loans to firms starting from € 25,000. By combining AnaCredit with data on ecosystem service dependencies, we can assess the extent to which banks are exposed to risks associated with the disruption of ecosys-

[6] Since the majority of non-financial firms in our sample have German domiciles, supply chains are set to originate in Germany, including domestic connections as well as retaining other countries and regions as upstream suppliers.

tem services. A total of just below 1,200 banks in Germany and an aggregated loan volume to non-financial firms of approximately € 1.7 trillion as of December 2025 compose our sample.

3.2 Methodology on dependency scores

This study evaluates the dependency of each bank's corporate loan portfolio on ecosystem services through a multi-step methodological approach. First, we convert the direct dependency scores for each economic sector into a numerical format. Second, we compute the indirect dependency scores for each sector by utilizing supply chain linkages. Third, the aggregation of these scores across sectors and banks is performed by weighting based on the lending volume. Consequently, scores are obtained on a scale from 0 to 1, where 0 indicates full independence from ecosystem services, and 1 signifies maximum dependency. We adopt the methodological approach outlined by Boldrini et al. (2023) for calculating dependencies. The methodological steps are explained in detail below.

3.2.1 Direct dependencies

Direct dependencies on ecosystem services at the sectoral level are sourced from the ENCORE dataset. The 271 economic sectors in the ENCORE dataset are reported as International Standard Industrial Classification of All Economic Activities (ISIC) codes, at either the level of class (level 4, highest precision on the activity) or group (level 3). To convert the ordinal ENCORE dependency scale into a numerical format, we apply the methodology established by Boldrini et al. (2023). Specifically, we rescale the categories as follows: Entries labeled 'N/A' (not applicable) are assigned a value of 0 because no dependency has been identified for these cases; 'very low' is mapped to 0.2; 'low' to 0.4; 'medium' to 0.6; 'high' to 0.8; and 'very high' to 1. Categories marked as 'ND' (no data) are treated as missing values because, though the relationship exists, insufficient data or references prevented the link to be quantified. Subsequently, the economic sectors encoded in ISIC are crosswalked into the Nomenclature of Economic Activities (NACE)[7] at division level (level 2) by calculating the arithmetic mean across all corresponding sectors, which provides a representation that balances outliers across the distribution of economic sectors. This crosswalk is necessary in order to ensure that sectoral dependen-

[7] AnaCredit is classified in NACE, requiring other datasets for the analysis to adopt this format.

cies can be matched with the loan data at a later stage, and results in a dependency matrix that comprises 88 economic sectors and their relationship with the 25 ecosystem services. Figure 1 illustrates the dependency matrix, which has been further aggregated to NACE sections (level 1, least granular with 21 distinct sectors) for simplification and a clearer visualization.

3.2.2 Indirect dependencies

To comprehensively assess banks' exposure to nature-related risks, it is essential to take not only direct but also indirect dependencies of economic sectors on ecosystem services into account. While direct dependencies reflect the immediate reliance of a sector on ecosystem services, many risks are transmitted indirectly through interdependent supply chains. For example, a food manufacturer may not directly depend on pollination, but if the supplying agricultural sector does, disruptions to this ecosystem service can still affect the food manufacturer's operations. Pinpointing these indirect links is therefore crucial for a holistic understanding of nature-related risks in bank lending (e.g., Svartzman et al., 2021; Boldrini et al., 2023).

Our approach quantifies these indirect dependencies by combining sector-level direct dependency scores with information on inter-sectoral linkages. We start by constructing a matrix of direct dependency scores (D) based on ENCORE data, where each entry ($D_{e,s}$) indicates the direct dependency of sector (s) on ecosystem service (e) (Natural Capital Finance Alliance, 2022). This matrix has dimensions (number of ecosystem services) × (number of sectors).[8] To trace how dependencies propagate through the supply chain, we use data from EXIOBASE (Stadler et al., 2018). The key analytical tool to be computed is the inverse Leontief matrix (L), which captures the total (direct and indirect) input requirements for each sector to produce one unit of output. It is calculated as $L = (I - A)^{-1}$, where A is the matrix of technical coefficients[9] retrieved from EXIOBASE, and I is the identity matrix.[10] Subtracting I from L allows us to examine the additional input requirements from other sectors in isolation (Leontief, 1970, 1986).

To ensure comparability across sectors, the resulting matrix $(L - I)$ is normalized

[8] The number of ecosystem services is 25, the number of sectors is 163 sectors.

[9] Technical inter-industry coefficients indicate how much input from each sector is needed to produce one unit of output in another sector.

[10] The identity matrix (I) is a square matrix with ones on the diagonal and zeros elsewhere, representing the baseline, or 'own sector' production.



Figure 1: Direct dependencies of economic sectors on ecosystem services.

and then combined with direct dependency scores. The matrix $(L - I)$ is normalized by a column-wise weighting, where each column entry is multiplied by the inverse of the column sum. Thus, the resulting normalized matrix $\overline{(L - I)}$ represents the relative importance of each sector in the supply chain (Svartzman et al., 2021; Boldrini et al., 2023). By multiplying the direct dependency matrix (D) with the matrix $\overline{(L - I)}$, we obtain the matrix of total upstream dependency scores (U): $U = D \times \overline{(L - I)}$. [11] Each entry ($U_{e,s}$) in this matrix denotes the indirect dependency of sector (s) on ecosystem service (e), accounting for all upstream linkages and weighting the importance of each sector accordingly. Figure 2 illustrates this dependency matrix, which has been aggregated from NACE level 2 (88 divisions) to level 1 (21 sections) for clarity and simplicity.

Although the direct dependency scores are not regionalized, the use of multi-regional input-output tables introduces a spatial dimension to the analysis. The structure of supply chains – and thus the make-up of indirect dependencies – can vary significantly with the geographic location of a sector. The resulting indirect dependency scores offer a comprehensive measure of how exposed each sector is to disruptions in ecosystem services via both the domestic and international supply chain.

3.2.3 Weighting with banks' corporate loan portfolio

Direct and indirect dependency scores are calculated as weighted averages, using loan volumes from AnaCredit as weights. One borrower is encoded with exactly one economic sector, and consequently, a bank extending credit to several borrowers in different sectors is presented with different sectoral dependency scores. At the most granular level of scores produced for our analysis, each bank's overall dependency score is computed by weighting sectoral dependency scores according to the loan volumes associated with each borrower ('Bank score'). This granular score provides the basis for further weighting and thus visualizing less disaggregated units of observations (i.e. bank categories, or the entire sample).

The sectoral composition of corporate lending determines the exposure to ecosystem services for each individual bank and bank category. As detailed in Section 3.1, AnaCredit not only offers a high granularity on loan-level information but contains the economic sector (NACE level 4) each borrowing firm belongs to. Within the scope of this analysis, only loans

[11] The resulting matrix U is of dimensions 25×163 which are crosswalked to NACE with dimensions 25×88.



Figure 2: Indirect dependencies of economic sectors on ecosystem services.

to non-financial firms are considered.[12] The plot in Figure 3 illustrates the relative sectoral composition of corporate lending of banks in Germany as of December 2025 and is organized by categories of banks. Among all categories of banks, the highest loan volume is extended to real estate activities. Real estate activities include the buying, selling, renting, and management of real estate, as well as real estate agency and valuation services, but exclude construction and architectural services. This is particularly pronounced among savings banks and credit cooperatives, which show the largest shares credited to this sector. In contrast, regional and other credit banks demonstrate a substantial allocation of loans to firms engaged in the sectors 'Wholesale and retail trade; Repair of motor vehicles and motorcycles'. Taking the category of banks 'Other institutions' into perspective, they lend significant shares to the sectors 'Manufacturing', 'Utilities', as well as 'Professional, scientific and technical activities'.[13]

4 Results

The dependency of banks' corporate lending is on average highest on ecosystem services that prevent soil erosion[14], while water-based ecosystem services[15], as shown in Figure 6, are also highly relevant. Figure 4 shows banks' direct and indirect dependencies on ecosystem services in descending order of relevance. The highest direct dependencies are determined for soil and sediment retention (0.47), visual amenity[16] (0.46), and storm mitigation (0.42).[17] Furthermore, ecosystem services that relate to water form a significant group within the direct dependencies. Five of the ten most significant ecosystem services relate either to water resources such as water flow regulation, water supply and water purification, or to water-regulating aspects such as flood mitigation and rainfall pattern regulation. Other studies also arrive at comparable results (e.g., Svartzman et al., 2021; Boldrini et al., 2023). The lowest

[12] It neither covers bonds that are held as fixed assets nor loans to private households.

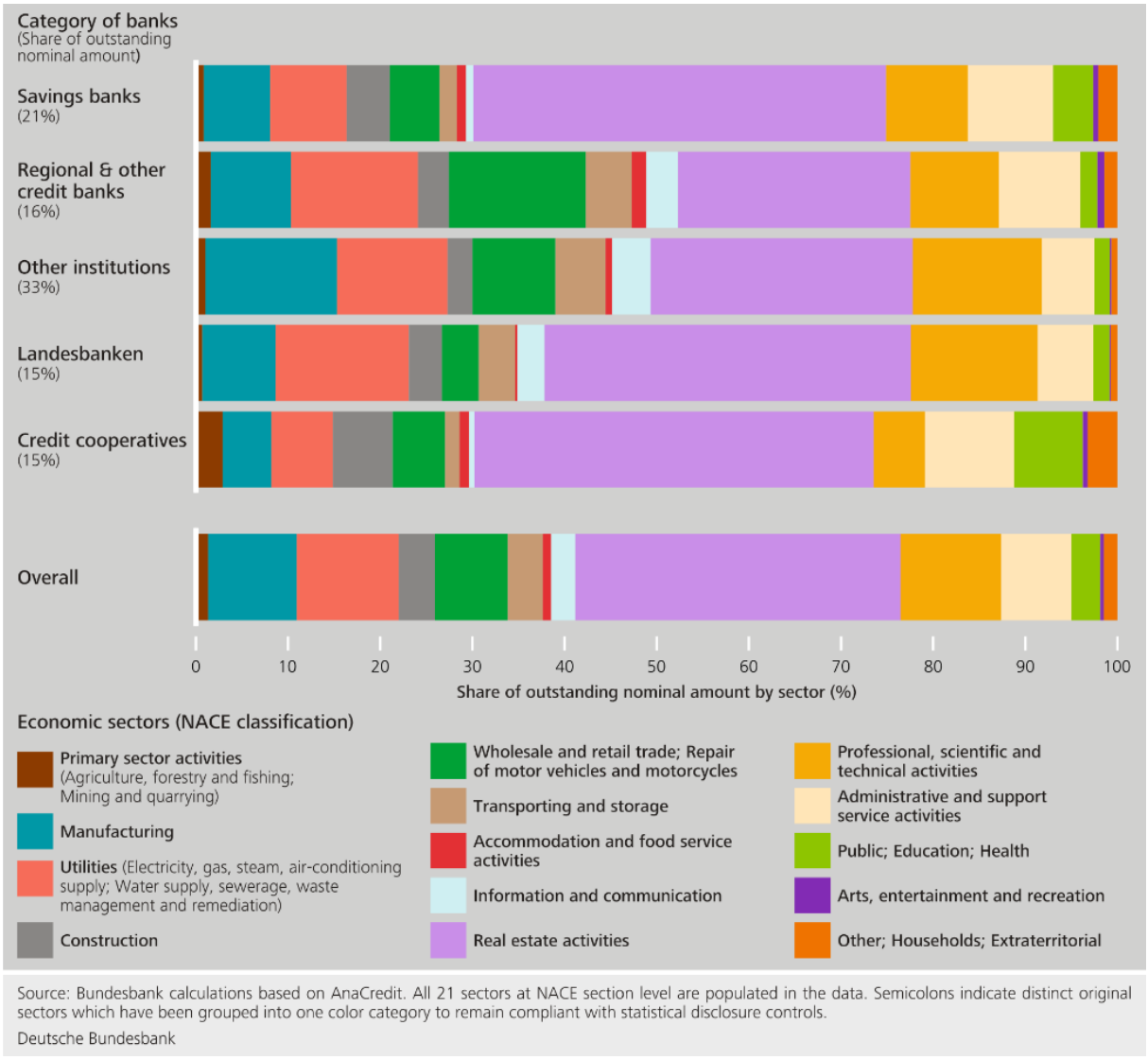
[13] Other institutions encompass a variety of financial entities, including big banks, branches of foreign banks, building and loan associations, banks with special, development, and other central support tasks, as well as both private and public mortgage banks.

[14] Effects of erosion include, among other things, the loss of fertile soil, impaired soil functions such as water and nutrient storage capacity, as well as water pollution (Umweltbundesamt, 2025a).

[15] Water-based ecosystem services are those for which water is essential for their functionality. 16 out of a total of 25 ecosystem services are based on the ecosystem component water, see ENCORE (2026b).

[16] Visual amenity is a cultural ecosystem service referring to the aesthetic value of natural landscapes. For example, a restored river corridor with diverse native vegetation enhances the scenic experience, promotes human wellbeing and and can improve cognitive function.

[17] For a detailed explanation of the ecosystem services see ENCORE (2026a).



Source: Bundesbank calculations based on AnaCredit. All 21 sectors at NACE section level are populated in the data. Semicolons indicate distinct original sectors which have been grouped into one color category to remain compliant with statistical disclosure controls.

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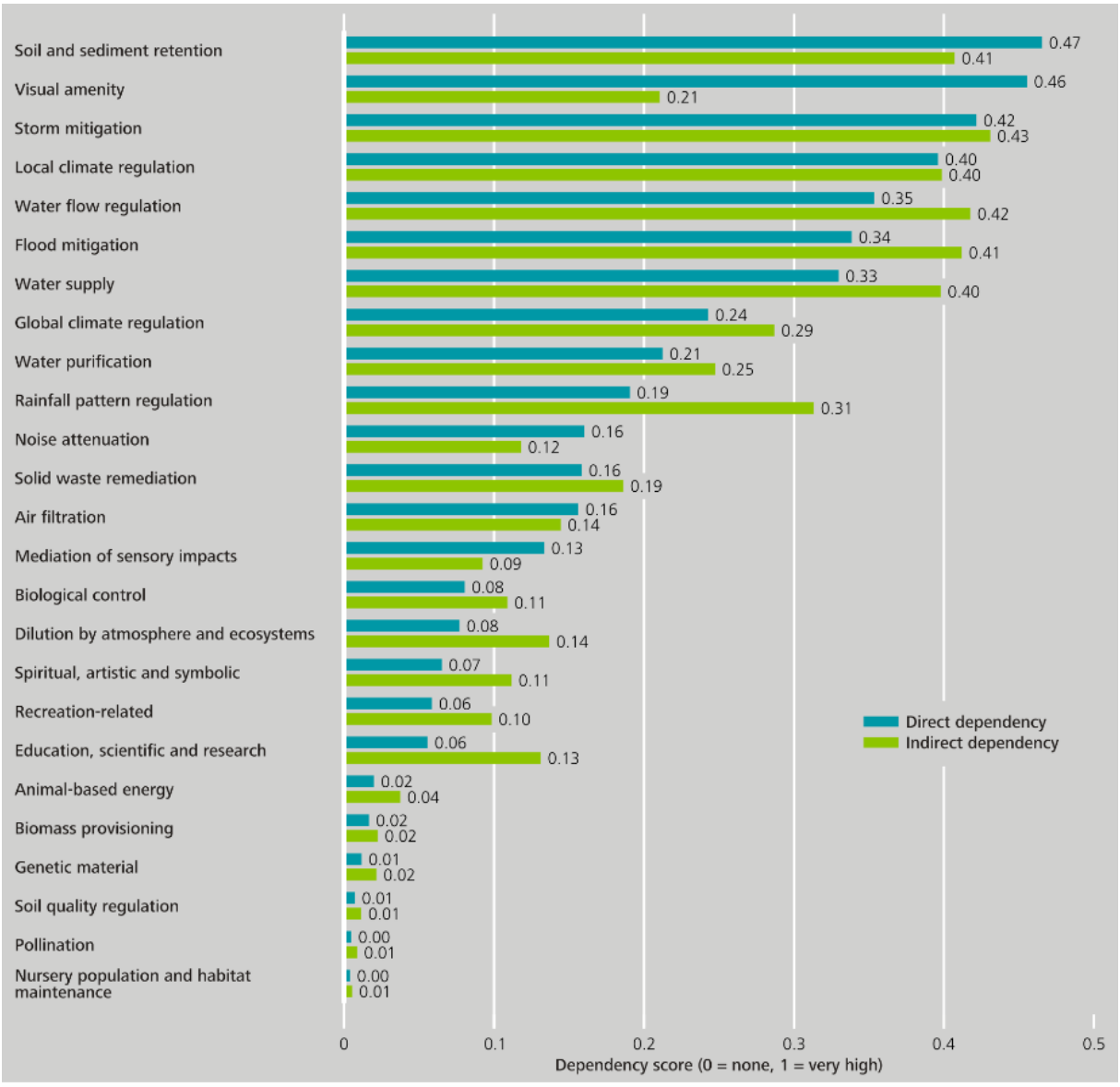
Figure 3: Sectoral composition of banks' corporate loan portfolios by category of banks.

direct dependencies are observed for soil quality regulation, pollination, as well as nursery population and habitat maintenance. In the Appendix, we provide a sectoral breakdown of the direct dependencies (see Figure 7).

An analysis of banks' indirect dependencies on ecosystem services reveals that ecosystem services that relate to water play a dominant role. The indirect dependencies displayed in Figure 4 indicate higher indirect than direct dependencies for all ecosystem services that relate to water mentioned above (water flow regulation, flood mitigation, water supply, water purification, and rainfall pattern regulation). For the majority of other ecosystem services – twenty in total – we also observe higher indirect dependencies compared to direct dependencies. This suggests that focusing solely on direct dependencies – without taking supply chain linkages into account – would underestimate the importance of ecosystem services, especially water, for economic activity. Notably, banks in Germany exhibit the highest indirect dependency on storm mitigation (0.43), followed by water flow regulation (0.42), and flood mitigation (0.41). The lowest indirect dependencies are observed for soil quality regulation, pollination, as well as nursery population and habitat maintenance, which aligns with the results on direct dependencies. In the Appendix, the indirect dependencies are presented by their sectoral composition (see Figure 8).

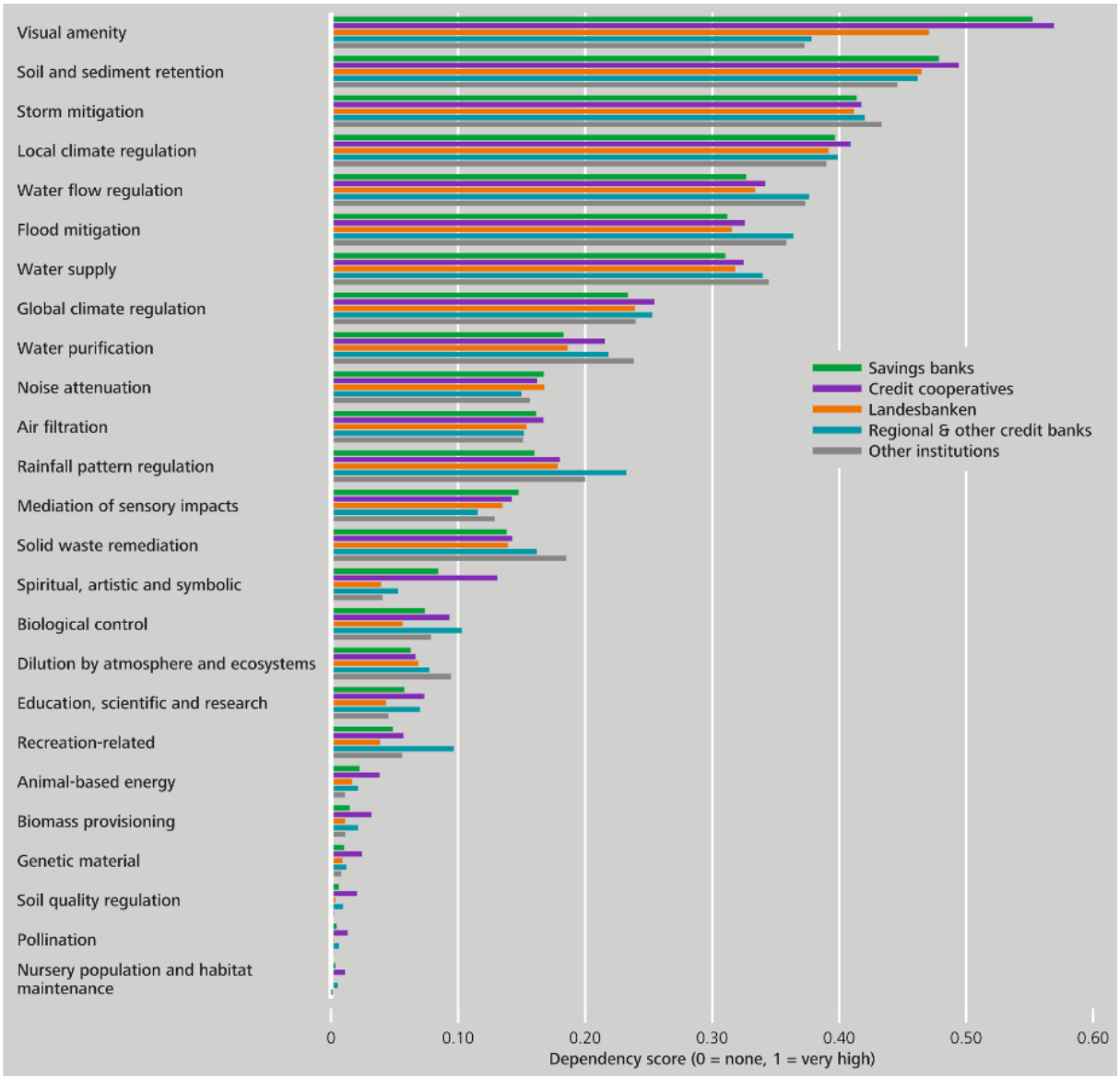
The extent of direct dependencies on ecosystem services exhibits partial variation across different categories of banks, with savings banks and credit cooperatives generally positioned at the higher end of dependency scores. Figure 5 illustrates the direct dependencies on ecosystem services for categories of banks separately. In particular, savings banks and credit cooperatives are more dependent on visual amenity as well as soil and sediment retention than other categories of banks. Regional banks and other credit banks appear to be particularly dependent on water flow regulation, water supply and flood mitigation compared to other categories of banks. However, for a set of ecosystem services, we observe very similar dependencies across all categories of banks, such as in case of storm mitigation. Overall, due to the focus of savings banks and credit cooperatives on firms based in their vicinity, nature-related dependencies may be concentrated in their corporate lending. As a result, it is crucial to better understand how the geographical focus of banks shapes their capacity to diversify risk, accounting for nature-related risks.

On average, slightly more than 52% of banks' corporate loan volume are characterized



Source: Bundesbank calculations based on ENCORE, EXIOBASE and AnaCredit. Values are rounded to two decimal places.
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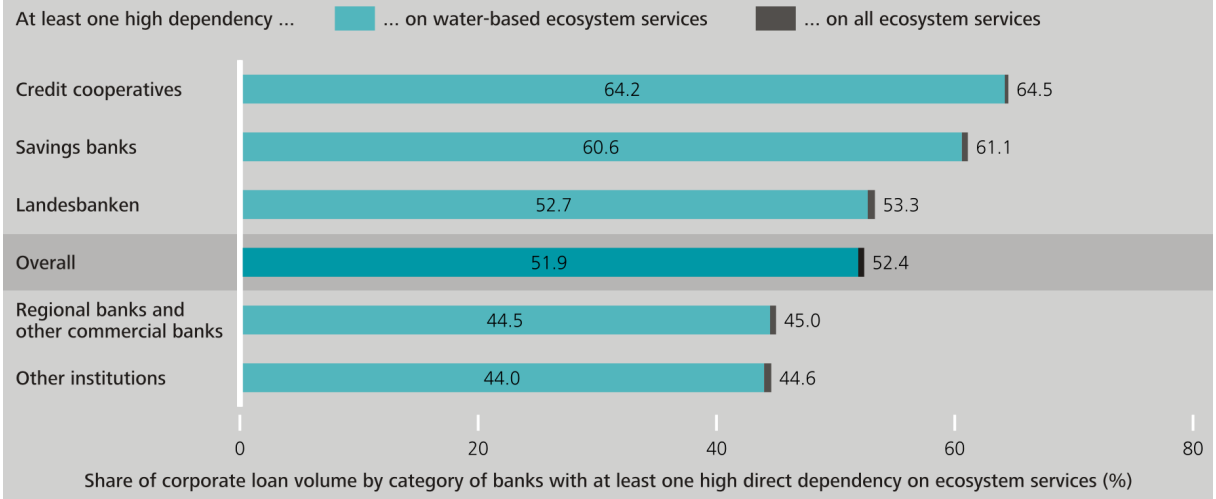
Figure 4: Direct and indirect dependencies of banks in Germany on ecosystem services through their corporate lending.



Source: Bundesbank calculations based on ENCORE and AnaCredit. Values are rounded to two decimal places.
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Figure 5: Direct dependencies of banks in Germany on ecosystem services through their corporate lending by category of banks.

by a high direct dependency on at least one ecosystem service, as shown in Figure 6. Following Boldrini et al. (2023), a high direct dependency on ecosystem services is defined as a degree of dependency greater than 0.7. It should also be noted that with marginally below 52%, the overall loan volume demonstrates a strong dependency on at least one water-based ecosystem service. These outcomes highlight the significance of water once more, such as its provision and regulation, as a prerequisite for economic activities. Among the categories of banks, credit cooperatives and savings banks present the largest shares with at least one high degree of dependency, both in relation to all ecosystem services, and with regard to water-based ecosystem services. Other institutions display the lowest proportion of corporate loan portfolios associated with at least one high dependency compared to the remainder of bank categories.



Source: Bundesbank calculations based on AnaCredit and ENCORE.
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Figure 6: High direct dependencies of banks in Germany on ecosystem services through their corporate lending by category of banks.

5 Conclusion

This study demonstrates that the banking sector in Germany is strongly dependent on ecosystem services through its corporate lending, particularly on those related to water. The findings reveal that banks are especially reliant on ecosystem services that prevent soil erosion and mitigate storm damages. The pronounced dependency on water-based ecosystem

services elevates the critical role of water as a prerequisite for economic activities. Remarkably, while direct dependencies are relevant, our analysis highlights that indirect dependencies – stemming from supply chain connections – in many cases play an even more prominent role. This underscores the necessity for banks to cultivate a more nuanced understanding of their dependency on ecosystem services.

Furthermore, our results indicate that savings banks and credit cooperatives exhibit higher dependencies on ecosystem services compared to other categories of banks. Since savings banks and credit cooperatives primarily lend to companies within their own regions, they may have less flexibility to adjust their lending practices and could therefore be more vulnerable to nature-related risks. Further examination of spatial disparities in water availability could provide deeper insights into the specific economic sectors – and the categories of banks associated with them – that are disproportionately affected by potential water stress, and whether such vulnerability could also translate into financial risks. Dependencies related to water are of special salience since, according to the German Environment Agency, Germany belongs to the regions with the highest water loss worldwide,[18] even though no water stress exists by definition.[19]

While these findings offer important insights, certain limitations should be acknowledged. This analysis focuses exclusively on banks' exposure to non-financial firms and their production of goods and services, omitting dependencies arising from lending to households and, thus, not including the consumer perspective as part of the economy. Due to consolidation in the crosswalk between economic sector classification systems, the sectoral resolution of our results is relatively coarse. Maintaining data granularity through refined mapping in future research would enable analyses that more accurately reflect firms' actual economic activities. Using sub-sectoral data on firms would allow to investigate how well they are able to mitigate nature-related risks and which adaptation capacities they possess.

Importantly, the dependencies identified in this study should not be interpreted as a direct measure of nature-related financial risk. Rather, they indicate potential channels

[18] Water loss occurs when the amount of precipitation is insufficient to compensate for evaporation or the runoff of water. Since the turn of the millennium, Germany has lost 2.5 giga tonnes or cubic kilometers of water per year. Combined over the 20 years from 2002 to 2021, this corresponds to the water volume of Lake Constance (Umweltbundesamt, 2023).

[19] If 20% or more of the renewable water supply is used, this is internationally referred to as water stress (Umweltbundesamt, 2025b; European Environmental Agency, 2025).

through which the degradation or loss of ecosystem services could affect firms and, ultimately, banks' loan portfolios. In principle, the severity of nature-related risks depends on whether functions of ecosystems services are lost partially, or whether they degrade completely beyond usability. To quantify potential economic and financial damages, future research should therefore seek to identify the sources of nature-related risks more precisely. This could be achieved by conducting more detailed analyses of the likelihood and extent of ecosystem service degradation. Incorporating spatially precise data on ecosystem stress, such as water provision, is key to locate regions with declining or potentially disrupted ecosystem services.

Building on these insights, combining such data of high spatial resolution with corporate domiciles and firms' activities would help identify where vulnerabilities reside. In a further step, it should be examined to which degree firms are able to adapt to such disruptions, for instance by substituting input factors or adjusting production processes. Site-specific and firm-level information can serve as a basis for banks to integrate nature-related risks into their risk assessment and strategic planning, thereby improving the management of their lending practices and increasing the resilience of their loan portfolios in the long term.

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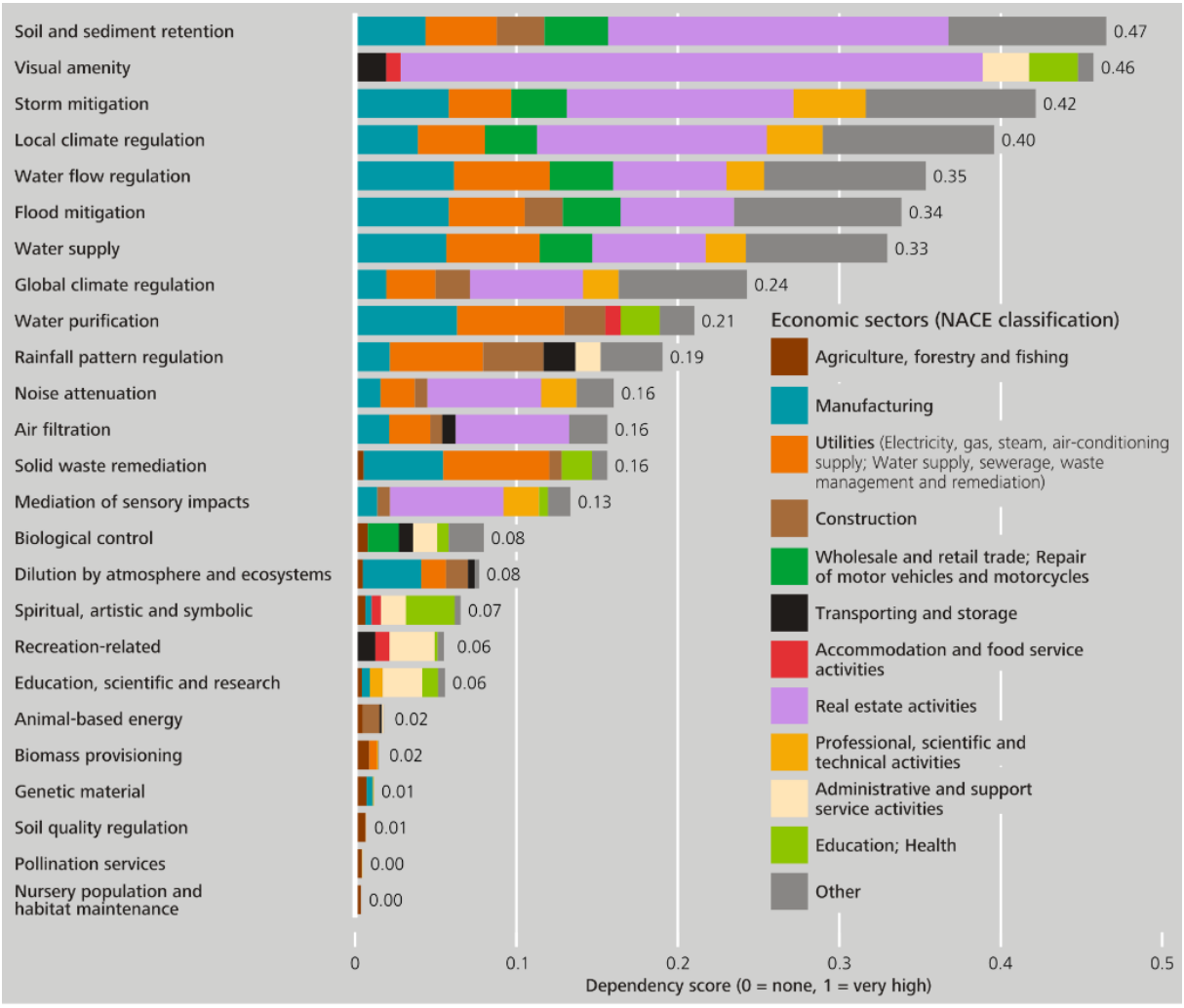
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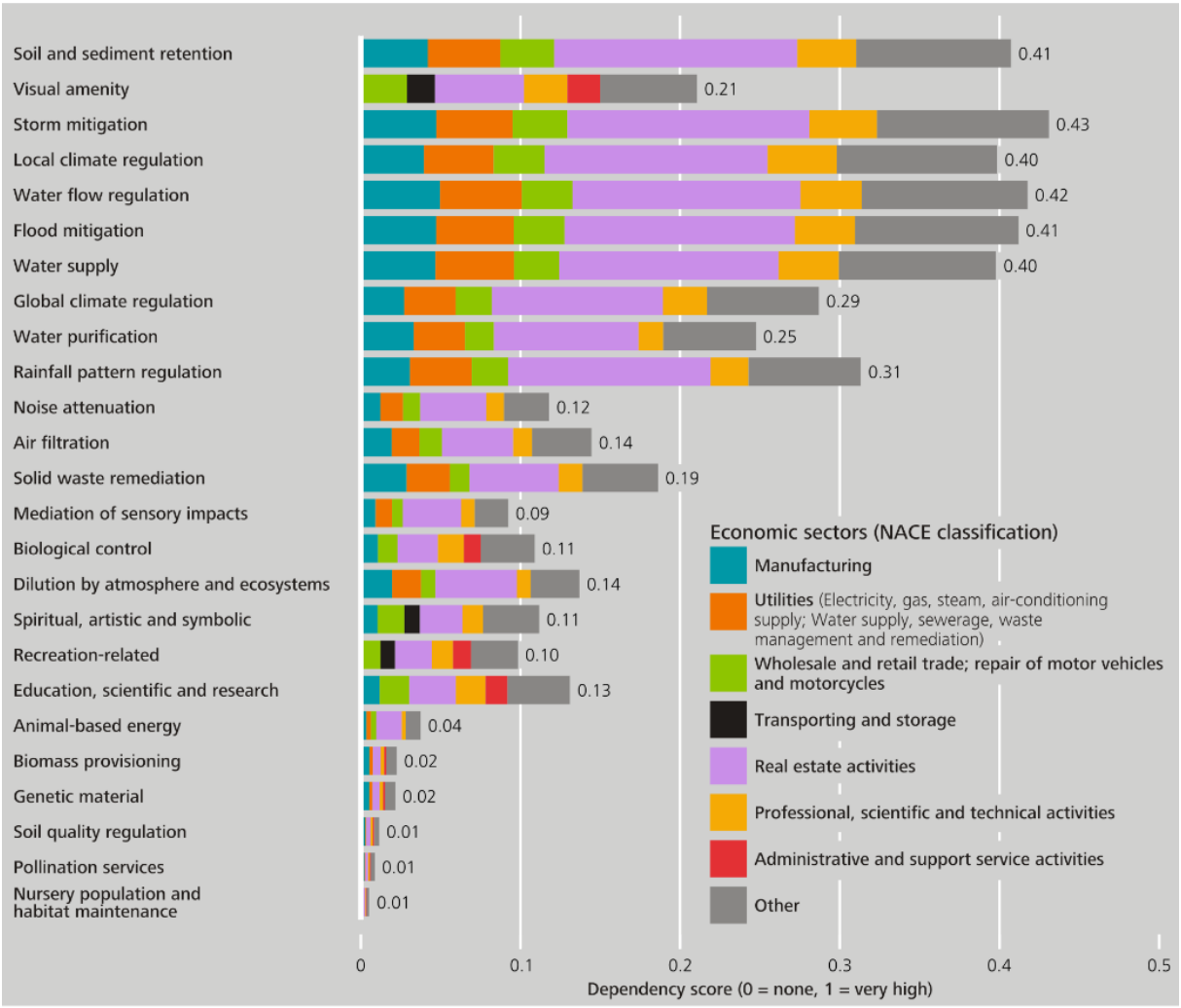
6 Appendix



Source: Bundesbank calculations based on ENCORE and AnaCredit. 13 out of 21 sectors at section level are populated in the data. Within each bar, up to 5 top sectors have been selected. Values are rounded to two decimal places.

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Figure 7: Direct dependencies of banks in Germany on ecosystem services through corporate loans by economic sectors.



Source: Bundesbank calculations based on ENCORE, EXIOBASE and AnaCredit. 11 out of 21 sectors at section level are populated in the data. Within each bar, up to 5 top sectors have been selected. Values are rounded to two decimal places.

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Figure 8: Indirect dependencies of banks in Germany on ecosystem services through corporate loans by economic sectors.