Managing Climate Risk Exposure:

Transition and Physical Climate Risks in Bank Loan Portfolios Across the Indonesian Banking System

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Key Takeaways:

- **Transition risk is persistent and global in nature.** A gradual domestic policy path limits near-term transition shocks, but global transition dynamics still transmit risk to fossil-intensive sectors and their lenders. Stress tests indicate a 35 percent potential increase in expected loss intensity due to carbon exposures, underscoring the need for ongoing monitoring of external drivers.

- **Policy clarity is essential to mitigate externally driven transition risk.** Clear long-term guidance on credible energy transition pathways can reduce uncertainty, improve risk pricing and capital allocation across sectors, and limit spillovers from global transition dynamics to the banking sector.

- **Physical climate risks are material, intensifying, and increasingly systemic.** Under the baseline climate scenario, large domestic commercial banks face projected flooding-related asset losses of around 0.4 percent annually by 2060, with risk accumulation intensifying thereafter. Projected losses are broad-based across sectors, including those conventionally viewed as less exposed. Under adverse climate scenarios, projected asset losses increase by more than 60 percent relative to the baseline.

- **Physical risk is magnified by concentrated borrower exposure.** Sharp variations in vulnerabilities across borrowers and asset locations mean that a small number of highly exposed assets can drive disproportionate portfolio losses. Sectoral, geographic, and project-level concentration further amplify tail risks under stress-testing scenarios.

- **Banks need more integrated frameworks and tools to manage climate risks.** The estimated climate-risk amplification is broadly in line with central bank climate stress-testing exercises elsewhere despite differences in modelling approaches, and by and large is higher than estimates for advanced economies, reflecting differences in policy context, economic development, and stage of transition. Robust financing structures and consistent, granular, asset-level data are essential for accurate risk pricing, provisioning, and capital planning, supporting effective and credible transition

Foreword

Climate risk has become one of the defining challenges for financial systems around the world. Banks today must navigate not only the rising costs of physical hazards such as floods and extreme weather, but also the profound implications of global and domestic transitions toward lower-carbon economies. These forces are reshaping credit risks, investment decisions, and the long-term resilience of financial institutions.

Indonesia provides a timely and important context for this study. As Southeast Asia's largest economy, it is simultaneously exposed to severe physical risks and undergoing a complex policy and energy transition, reflecting both high exposure to climate risks and material emissions intensity. Understanding how these forces interact with the banking sector is critical. Heterogeneity in the sectoral, geographic, and borrower composition of bank loan portfolios governs the transmission of physical and transition risks into expected losses.

This study offers a holistic analysis combining bank loan portfolio data, transition policy assessments and risk modelling, and climate-related physical risk modelling. Two critical findings emerge for policymakers and industry participants. First, while physical risk exposure remains relatively moderate across the banking sector through 2060, some portfolios exhibit higher tail risks. Beyond 2060, however, the severity of physical risk exposure rises sharply, with climate impacts accelerating across nearly all sectors. Second, despite uneven domestic policy progress, climate transition risk poses a more immediate challenge: fossil-intensive sectors such as coal, oil and gas, and electricity exhibit significantly higher default risk and expected credit losses than other sectors, posing a potential source of systemic transition risk for the banking sector.

These insights highlight the need for financial institutions to adopt forward-looking approaches that incorporate both near-term transition pressures and longer-term physical risks. We hope this work contributes to strengthening risk management frameworks and supporting more resilient financial systems in an era of accelerating climate change.

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Executive Summary

With unprecedented increases in the frequency and severity of extreme weather events around the globe, it is undeniable that climate change is here to stay. These extreme events have prompted governments and international organizations, including the United Nations, to place greater emphasis on physical and transition affecting industries and economies in both the near term and the longer run.

One country particularly exposed to these evolving climate dynamics is Indonesia. As an equatorial archipelago of low-lying islands, with major cities and industry activities concentrated along its coastlines, Indonesia is highly exposed to sea level rise and flooding risks, which has been exacerbated by climate change. In addition, Indonesia's economic structure remains heavily reliant on export-oriented, fossil-intensive sectors, with an energy mix dominated by fossil fuels. At present, progress toward a clear and systematic transition plan to support net-zero objectives remains limited and uneven, in part due to competing policy priorities.

This paper assesses the transition and physical climate risks currently embedded in Indonesia's banking sector. A gradual domestic policy path in Indonesia limits near-term transition shocks, but global transition dynamics still transmit risk to fossil-intensive sectors. Considering Indonesia's current data environment, we adopt a statistical approach to conduct transition stress testing, incorporating observed volatility in probabilities of default (PDs) across sectors. Borrowers in the coal, oil, gas, and electricity sectors experienced larger PD shocks during periods of heightened volatility, translating into disproportionately higher increases in expected losses relative to other sectors. This pattern is consistent with heightened sensitivity to global decarbonisation pressures in sectors with high fossil dependence and limited transition readiness.

From a risk management and supervisory perspective, these findings point to market volatility as a key transmission channel for transition risk, resulting in adverse repricing and default shocks in these sectors. In this context, stress tests indicate a 35 percent potential increase in expected loss intensity. These findings underscore the need for stronger provisioning approaches, explicit consideration of transition exposures in capital-planning frameworks, and ongoing monitoring of external drivers.

Climate-related physical risk exposures of borrowers' assets are also likely to increase over time, particularly through hazards that are both highly probable and economically consequential. We therefore focus on flooding as a pilot physical risk, given its prevalence and clear transmission to financial outcomes in Indonesia, reflecting the country's low-lying geography, coastal concentration of economic activity, and historically high rainfall. Using forward-looking climate scenarios, we assess how escalating flood risk may impair borrowers' asset values, which will ultimately feed into higher expected losses in bank loan portfolios. By 2060, large domestic commercial banks face projected asset losses averaging around 0.4 percent annually under the SSP2-4.5 scenario, with risk accumulation intensifying thereafter. Under more adverse climate scenarios, projected asset losses increase by more than 60 percent. These losses accumulate through multiple sectors – including those conventionally viewed as less exposed – and impact borrowers disproportionately, generating uneven risk profiles within each bank's loan portfolio.

Through this comprehensive analysis, we provide a clearer picture and amplification indicators of climate risk in Indonesian banking system's so managers can transition toward decarbonisation and identify potential policy actions to address remaining gaps in climate transition and resilience frameworks.

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List of Abbreviations

AIDF – CRI	Asian Institute of Digital Finance – Credit Research Initiative
BCA	Bank Central Asia
BICS	Bloomberg Industry Classification Standard
BNI	Bank Negara Indonesia
BPD	Bank Pembangunan Daerah – *Regional Development Bank*
bps	Basis points
BRI	Bank Rakyat Indonesia
CCS	Carbon Capture and Storage
DFI	Development Finance Institution
EAD	Exposure at Default
ECB	European Central Bank
EL	Expected Loss
ICT	Information and Communication Technology
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IRBI	Indeks Risiko Bencana Indonesia – *Indonesia Disaster Risk Index*
ISIN	International Securities Identification Number
JETP	Just Energy Transition Partnership
LGD	Loss Given Default
LTS-LCCR	Long-Term Strategy for Low Carbon and Climate Resilience
NACE	Nomenclature of Economic Activities
NDC	Nationally Determined Contribution
NGFS	Network for Greening the Financial System
OECD	Organisation for Economic Co-operation and Development
OJK	Otoritas Jasa Keuangan – *Financial Services Authority*
OPEC	Organization of the Petroleum Exporting Countries
PD	Probability of Default
PLN	Perusahaan Listrik Negara
PPA	Power Purchase Agreement
RCP	Representative Concentration Pathway
RUKN	Rencana Umum Ketenagalistrikan Nasional - *National General Electricity Plan*
RUPTL	Rencana Usaha Penyediaan Tenaga Listrik - *Electricity Supply Business Plan*
SIC	Standard Industrial Classification
SNDC	Second Nationally Determined Contribution
SSP	Shared Socioeconomic Pathway
TPI	Transition Pathway Initiative
TRS	Transition Readiness Scorecard
UNFCCC	United Nations Framework Convention on Climate Change

Glossary

Climate Scenario

A structured set of assumptions describing possible future pathways for climate policy, emissions, technology, physical hazards, and macroeconomic variables. Scenarios (e.g., NGFS, IPCC) are used to assess how different futures would affect financial risks.

Coastal Flood

Flooding caused by storm surge, sea-level rise, or extreme tidal events in coastal areas. It primarily affects low-lying zones near the shoreline.

Credit Risk

The risk of financial loss arising from a borrower's failure to meet its obligations in full and on time. Credit risk depends on the borrower's probability of default, the exposure at default, and the loss given default.

Fluvial Flood

Flooding that occurs when rivers or streams overflow their banks due to heavy rainfall or upstream runoff.

Loss Given Default

The share of exposure that is lost if a borrower actually defaults. It reflects how much the lender does not recover after collateral, guarantees, and any restructuring, usually expressed as a percentage of the exposure at default.

Loss Intensity

Expected loss normalised by its corresponding loan exposure, provides a sector-adjusted measure of vulnerability and is typically reported in basis points (bps).

Physical Risk

Climate-related risks arising from acute events (e.g., storms, floods, heatwaves) and chronic changes (e.g., sea-level rise, long-term temperature increases) that can damage assets, disrupt operations, or impair borrower cash flows.

Pluvial Flood

Surface flooding caused by intense rainfall that overwhelms drainage systems, even when rivers are not overflowing. Often occurs in urban areas with poor drainage.

Probability of Default

The likelihood that a borrower will fail to meet its debt obligations over a given time horizon (for example, within one year). It is usually expressed as a percentage (e.g. 2 percent PD).

Projected Asset Loss

Projected Asset Loss refers to the annual projected loss on a borrower's asset due to flooding hazards, for specific "checkpoint years" (e.g., 2050, 2090) under defined Shared Socioeconomic Pathways (SSP scenarios). At the sector and bank portfolio levels, Projected Asset Loss is calculated as an exposure-weighted average of individual borrower-level losses.

Standard Deviation/Sigma

A statistical measure of how much values vary around their average. In risk analysis, a "1σ" or "2σ" shock typically refers to moving PDs or other risk factors by one or two standard deviations away from their historical mean.

Stress Test

An analytical exercise that applies adverse but plausible scenarios (for example, a severe climate policy shock or a large physical hazard event) to assess how a bank's loan book, capital, or earnings would respond under stress.

Tail Risk

A low-probability but high-impact risk event located in the "tails" of a probability distribution. In climate-risk analysis, tail risks capture extreme but plausible shocks such as abrupt policy tightening or severe hazard events.

Transition Risk

Climate-related risks that arise from the economic and policy transition towards a low-carbon economy. They include changes in climate policy, carbon pricing, technology, and market preferences that can reduce the profitability or value of high-emitting sectors.

Tranche

A tranche is one "slice" or portion of a larger loan. In a syndicated loan, the total amount is split into several tranches, each with different terms – for example, different interest rates, currencies, maturities, or levels of risk (senior vs. subordinated). Bloomberg and Refinitiv report commitments at the tranche level, so a single borrower may appear multiple times in the loan book.

Chapter I

Introduction

I.   Introduction

Recent trends show an alarming escalation in natural disasters across the globe, each manifesting through different forms of physical climate risk. North America is experiencing unprecedented wildfires, Southern Europe continues to battle record-breaking heatwaves, Pakistan has suffered devastating flash floods, and the Philippines faces increasingly intense typhoons. These events are no longer isolated anomalies; they are occurring more frequently, at larger scales, and with far greater destructive power than in previous decades. The global pattern makes clear that physical climate risks are accelerating and becoming a central concern for governments, businesses, and communities.

When considering national strategies to address climate change, countries may differ in their approaches to transition risks, such as net zero target, carbon pricing mechanisms, or industrial restructuring. However, physical risks tend to be far more uniform in their manifestation: flood, heat, drought, storm, wildfire, and sea level rise do not differentiate by political boundary. This universality suggests that addressing physical climate risks is equally important, if not more urgent, than addressing transition risks, especially for economies where climate impacts are already eroding productivity, infrastructure, and social well-being.

The magnitude of physical risk faced by a firm is further amplified by geographical exposure. For instance, heavy rainfall and poor drainage can turn flood-prone regions into recurring disaster zones, and if many businesses or communities are clustered around such areas, the economic and social damage compounds rapidly. This spatial vulnerability is a critical factor in determining the resilience or fragility of entire sectors.

Interestingly, certain industries exhibit strong tendencies to operate in locations that are inherently more physically exposed. Coal-fired power plants, for example, are often built near coastlines to ease the logistics of coal. However, this also places them directly in the path of rising sea levels, storm surges, and coastal flooding. Similarly, nickel mining, particularly open-pit operations common in Southeast Asia, often occurs in mountainous or forested areas where excavation destabilises soil structures and increases the likelihood of landslides and flash floods. These patterns reveal a structural linkage between industry characteristics and climate-related physical exposure.

1.   Climate Risk for Banks

Exploring these linkages more deeply could provide valuable insights for financial institutions, particularly banks, as they make decisions about how to distribute financing across their portfolios. While banks may not be directly exposed to physical risks, they are indirectly affected through the vulnerabilities of the companies they lend to. Operational disruptions, asset damage, supply-chain breakdowns, and productivity losses arising from natural disasters can significantly elevate borrowers' credit risk, increasing the likelihood of repayment difficulties and default from a banking perspective. Over time, these risks accumulate at the portfolio level, with their severity depending heavily on the degree of sectoral concentration, whether a bank is disproportionately exposed to industries operating in physically high-risk areas.

A similar dynamic applies to transition risks. As economies move toward lower-carbon pathways, borrowers in fossil-intensive sectors may encounter higher compliance costs, mandated phase-outs, or stranded asset risks. These pressures can erode profitability and cash flows, reduce collateral values, and increase the likelihood of default. Banks may also face legal, regulatory, and reputational consequences if they

or their portfolio companies fail to meet climate-related requirements. Together, these effects underscore why transition risk is just as material as physical risk in shaping portfolio resilience.

Given the combination of physical and transition risks across different locations and sectors, a well-diversified portfolio can help reduce the likelihood that climate shocks originating in a particular industry spill over into broader financial instability. Incorporating physical risk assessments into sector-level credit reviews, stress testing, and capital allocation strategies is therefore an essential component of responsible risk management, especially as climate impacts intensify.

However, banking decisions on sector exposure are not always driven purely by commercial or risk-based considerations. In some markets, particularly those with less market-liberalised financial systems, banks may be mandated to support national development priorities, strategic sectors, or industrial programmes, even when such sectors carry higher physical climate risks. State-owned banks, in particular, may face political or regulatory pressures to finance projects aligned with government objectives, including energy, mineral extraction, or infrastructure sectors that are naturally more vulnerable to floods, or drought. When government strategies do not explicitly address transition risk, banks may drift further from climate-aligned portfolio management. As a result, these institutions may become disproportionately exposed to industries with elevated physical risks, increasing their vulnerability to climate-related credit losses. Recognising these dynamics highlights the importance of integrating climate risk into public-sector banking policies, national financial regulations, and sustainable finance strategies.

2. Focus on Indonesia

Indonesia presents a particularly compelling case for studying the intersection between physical climate risks and sector-level exposure. Geographically located along the equatorial belt, the country experiences extremely high rainfall and is highly prone to flooding. According to World Bank report (2021), 1.4 million of the population will be exposed to an extreme river flood by 2035. Its vast peatlands support large-scale palm cultivation for palm oil production. However, this has also led to significant deforestation and land-use change, making peatlands more vulnerable to recurring wildfires. These climate-related risks are further intensified by cyclical natural phenomena such as El Niño and La Niña, which amplify the severity of both droughts and floods, creating prolonged and devastating environmental impacts.

From a sectoral exposure perspective, Indonesia hosts a large concentration of companies in highly climate-exposed industries, particularly energy and mining. These sectors remain central to the country's economic structure and fiscal stability. Although Indonesia is formally no longer a member of the Organization of the Petroleum Exporting Countries (OPEC), its oil and gas sector remains active, with Pertamina standing as the country's largest state-owned enterprise. Indonesia also possesses the world's largest nickel reserves, making it a global hub for nickel mining and processing, particularly as demand rises for electric vehicle battery supply chains. Coal mining further underscores Indonesia's exposure to climate risk. It currently remains the dominant energy source for national electrification, with coal activities contributing roughly 2–4 percent of Indonesia's Gross Domestic Product (GDP) and 10–15 percent of its total export revenues.

Lastly, Indonesia's banking sector is heavily influenced by the presence of state-owned banks whose mandates often include supporting strategic industries such as coal and mining sectors that contribute significantly to national income. Three of the four largest banks in the country – Bank Mandiri, Bank Rakyat Indonesia (BRI), and Bank Negara Indonesia (BNI) – are state-owned, with Bank Central Asia (BCA) being the only major privately owned domestic institution among them. In line with government priorities, financing to coal and mining activities has surged in recent years as part of broader efforts to strengthen fiscal revenues and maintain energy security. This concentrated exposure reinforces the systemic importance of understanding transition and physical climate risks, as disruptions in these climate-vulnerable sectors could have wide-ranging implications not only for borrowers, but also for the stability of Indonesia's broader financial system.

These interlinked dynamics of escalating physical hazards, uneven transition pathways, and structurally concentrated sectoral exposures, underscore why a focused examination of climate risk within Indonesia's financial system is both timely and necessary. As climate impacts intensify, the vulnerabilities embedded within banks' lending portfolios will increasingly influence credit quality, capital adequacy, and long-term financial stability. Yet despite the scale of these challenges, there remains a critical gap in understanding how physical and transition risks jointly accumulate at the sector level, how they differ across borrowers, and how they may unfold within portfolios dominated by strategic but climate-exposed industries. A rigorous, data-driven assessment is therefore essential, not only to identify where risks are concentrated, but also to support banks, regulators, and policymakers in designing forward-looking strategies that strengthen resilience across Indonesia's financial landscape.

The remainder of this report is structured to address these issues systematically. Chapter Two presents a detailed overview of Indonesian banks' lending portfolios, highlighting the extent of sectoral concentrations that shape their exposure to climate-related risks. Chapter Three examines Indonesia's transition landscape and outlines the methodological approach for modelling transition risk through probability-of-default stress testing. Chapter Four turns to physical risk, with a particular focus on flood hazards, and assesses how location-specific climate impacts translate into financial vulnerabilities for firms and, by extension, their lenders. The final chapter synthesises these findings and offers policy and supervisory recommendations to enhance climate-risk management within Indonesia's banking sector.

Chapter II

Bank Portfolio

II.   Bank Portfolio

The bank portfolio represents the set of borrower-level credit exposures that constitute each institution's outstanding lending activities. Understanding the structure and composition of these portfolios is a necessary foundation for any assessment of climate-related financial risks. Both transition and physical risk impacts depend on how credit is allocated across sectors, firms and geographies, making an accurate representation of portfolio exposures a prerequisite for quantifying potential loss channels and comparing risk profiles across banks.

While banks and central banks generally disclose portfolio composition at an aggregated sectoral level, climate risk analysis requires substantially higher granularity. Physical risk is location dependent, reflecting exposure to hazards that vary with the geographic distribution of firms' operational assets, such as proximity to coastlines and topography. Firms operating in the same sector can exhibit markedly different levels of physical hazard. Transition risk is similarly heterogeneous. Policy measures and decarbonisation requirements affect firms unevenly, depending on their technological profile and progress toward net-zero commitments. A borrower-level representation of credit exposures is thus essential for assessing climate-related financial risks, since both risk channels operate at a level of detail that aggregated portfolio statistics cannot capture.

Many jurisdictions require banks to report borrower-level credit information to supervisory authorities. For example, the European Central Bank (ECB) collects loan-by-loan data through AnaCredit under Regulation (EU) 2016/867[1], and Otoritas Jasa Keuangan (OJK) operates the Financial Information Service System (SLIK) credit registry [2] in Indonesia. These datasets are sufficiently granular for asset-level analyses, but they are subject to strict confidentiality rules and are not publicly disclosed at the level of identifiable borrowers. With publicly available disclosures remain aggregated, researchers face a high degree of difficulty in reconstructing banks' portfolios from supervisory registries.

Given these constraints, our analysis begins by reconstructing bank portfolios using only publicly accessible information and attributing exposures to individual borrowers to the extent possible.

1.   Data Sources

The analysis draws on publicly available corporate loan information obtained from **Bloomberg and Refinitiv**. Both data providers aggregate loan information from bank filings, public sources, and proprietary data-collection efforts. Both datasets comprise of transaction-level data on corporate lending, including facility characteristics, borrower identities, lender participation, maturity profiles, and deal sizes. Refinitiv incorporates DealScan loan records, a widely used source of commercial loan information, while Bloomberg maintains a comparable dataset covering global loan issuances. The primary coverage of both databases are syndicated loans, although both also include a limited number of bilateral loan facilities.

The datasets provide only partial coverage of the Indonesian loan market and are concentrated in syndicated transactions which typically are borrowed by large corporates. Large corporates account for a significant portion of bank loan portfolios in Indonesia. According to the International Monetary Fund (IMF), corporate lending accounts for 60 percent of lending in Indonesia, of which 40 percent are issued to large corporates[3]. As such, these databases contain information on bank loans to borrowers whose

exposures are likely to be material for climate-risk analysis at the loan portfolio level and offer a practical basis for analysing bank loan portfolios given data availability constraints.

2. Scope and Sample Definition

The reconstructed portfolio covers loan facilities extended to Indonesian corporate borrowers, irrespective of the nationality of the lending institution. The sample comprises of syndicated loans and a limited number of bilateral facilities recorded in Bloomberg and Refinitiv. Exposures to sovereign entities and households were excluded to maintain analytical focus on corporate credit risk.

The dataset excludes cancelled, withdrawn, and rumoured deals, as well as transactions for which no loan size information was available. To reflect credit relationships relevant for climate risk assessment, only facilities with a contractual maturity on or after 1 January 2015 were retained.

Unless otherwise specified, all subsequent analysis is based on a snapshot of **credit exposures as of 1 January 2025**. For simplicity, the analysis assumes that lending patterns remain unchanged over the horizon and do not adjust endogenously in response to structural economic developments or climate-related shocks.

3. Portfolio Construction Methodology

Loan Dataset Harmonisation

Loan records from Bloomberg and Refinitiv were first harmonised to create a unified transaction-level dataset. Because loans are not publicly traded instruments, they lack universal identifiers such as International Securities Identification Numbers (ISINs) or Committee on Uniform Securities Identification Procedures (CUSIPs). Loan datasets often differ due to proprietary data-collection processes and manual inputs. As a result, borrower names, lender names, and deal attributes may not always align across sources. To resolve inconsistencies, records were aligned using core borrower information and loan terms. Overlapping entries were consolidated, and duplicates were removed, resulting in a clean, unified dataset. The harmonized dataset contains **17,415 tranche-level observations from 2015 to 2025Q1**, totalling USD 647 billion in commitment amount.

Borrower Business Classification

Borrowers were mapped up to Nomenclature of Economic Activities (NACE) business classification, L1 sectors and L2 industries, drawing reference to SIC and BICS classifications provided by Refinitiv and Bloomberg respectively, supplemented with public information to ensure that sector assignments reflect their primary economic activities. For mining and smelting companies, the specific mineral types are included through public information research. For diversified or conglomerate groups, a single classification was assigned based on the dominant revenue-generating activity, recognising that this may not fully capture the breadth of operations across multiple sectors. For the ease of presentation, "Telecommunication, Computer Programming, Consulting, Computing Infrastructure, and other Information Service Activities" is labelled as "Information and Communication Technology (ICT)" for this report.

Lender Participation and Exposure

For syndicated loans, each tranche typically involves multiple participating lenders. Lender identities were extracted from participant lists reported in Bloomberg and Refinitiv. Both datasets provide commitment information at the tranche level, indicating each participant's name, roles, and, where available, their committed amount. In our harmonised dataset, 70.4 percent of tranches contain complete participant-level commitment data. For the remaining 29.6 percent, tranche-level commitments were extrapolated

using tranches with complete information. The estimation incorporates tranche size, the role of the participant and the distribution of participant roles to derive lender-level shares where commitment amounts were not explicitly reported.

Participating entities, including their branches, were mapped to consolidated banking groups. Unidentifiable lenders, which are common in syndicated loan disclosure, are labelled as undisclosed without estimation.

Exposure Estimation

Loan exposure is defined as the outstanding value of credit provided to borrowers. Exposures were calculated at the tranche level. For each tranche, exposure is calculated based on the outstanding principal as of the reference date (1 January of each year) together with accrued interest since the last payment date. Loans that were both originated and expected to be fully repaid within the same year do not contribute to any exposure in the year-start snapshots. The commitment amounts are assumed to be fully drawn.

Both Bloomberg and Refinitiv datasets do not provide information on loan repayment. Principal amortisation is assumed to follow a straight-line schedule with equal semi-annual repayments starting from the issuance date. Accrued interest is estimated as the sum of contractual spread and the average three-month benchmark rate of the tranche's denominated currency over the 2015 to 2024 period. Examples include 3M Chicago Mercantile Exchange (CME) Term Secured Overnight Financing Rate (SOFR) for USD and 3M Jakarta Interbank Offered Rate (JIBOR) for IDR. When spread information was unavailable, the median spread observed in the corresponding NACE L2 industry over the same period was applied.

Consolidation at the Borrower-Lender Level

The tranche level exposure is consolidated at the borrower-lender level to produce bank-specific borrower-level exposure profiles. For borrowers with multiple loan tranches, exposures were summed across all active loans.

4. Harmonized Dataset Coverage

The harmonised dataset provides broader coverage than either source individually and improves data quality for overlapping transactions by allowing missing fields in one dataset to be supplemented by information from the other.

The analysis below was performed on all loans with final maturity no earlier than January 2025, unless otherwise stated.

Sectoral Coverage by Data Source

Figure 1 shows that both Bloomberg and Refinitiv capture similar sectoral lending patterns, with electricity, mining, and manufacturing emerging as the largest recipients of loan commitments. Yet the green bars reveal that only a modest portion of these commitments is jointly reported by both sources, implying that each provider captures distinct parts of the market. Figure 2 reinforces this point that tranche-level overlaps remain limited. This partial overlap indicates that the corporate loan market is not uniformly captured by either dataset. By merging the two, the harmonised dataset broadens sectoral coverage and strengthens the representativeness of the portfolio foundation used for subsequent climate-risk analysis.

Figure 1 Data Source Coverage by Sector (Commitment)
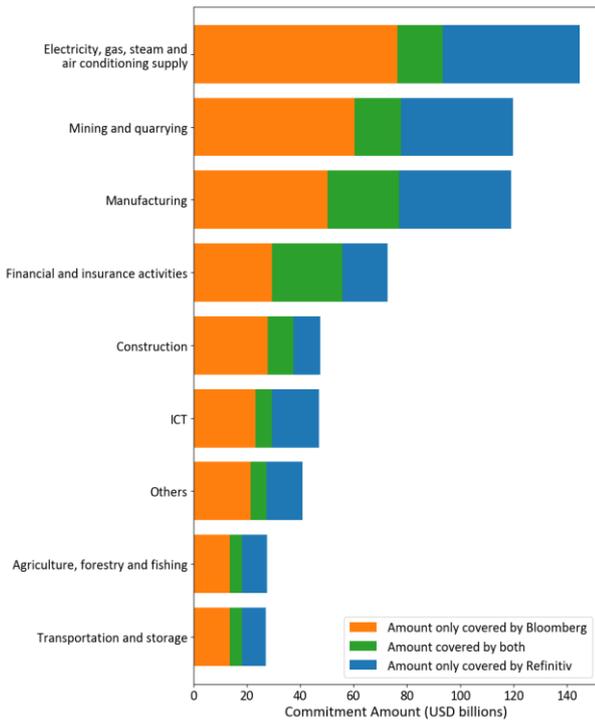
Figure 2 Data Source Coverage by Sector (#Tranches)
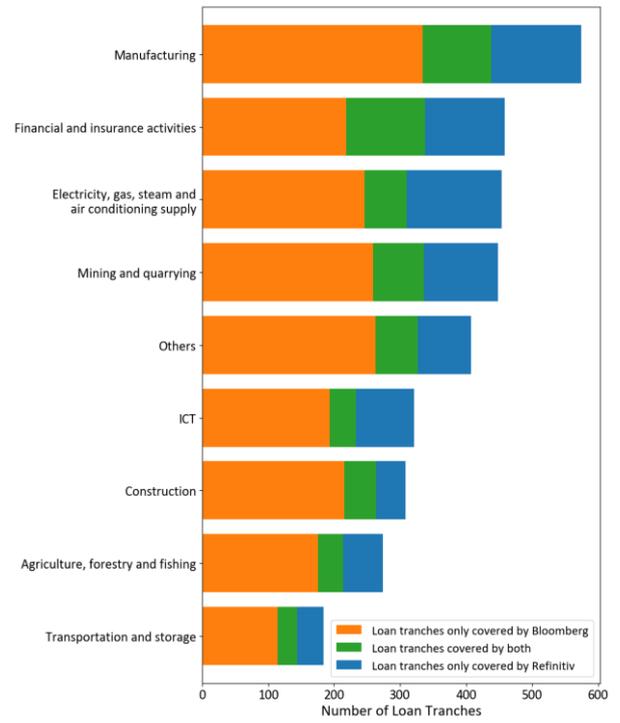
Company-Level Coverage by Data Source

Refinitiv and Bloomberg also complement each other at the company level. Figure 3 shows commitment amounts ranked using Bloomberg data (orange and green), with the blue segments illustrating additional commitments captured only by Refinitiv. To aid interpretation, companies are split into the top 50 (largest commitments) and the remaining 51–716 to highlight how

coverage patterns differ between large and mid-sized borrowers. A cluster of companies at the bottom right corner is covered exclusively by Refinitiv. Figure 4 shows a similar pattern for tranches counts, where the top 50 (most number of tranches) are displayed separately. Overall, both charts shows that the harmonised dataset provides add meaningful coverage, particularly for mid-sized companies where Refinitiv offers more commitment and tranches.

Figure 3 Data Source Coverage by Company (Commitment)
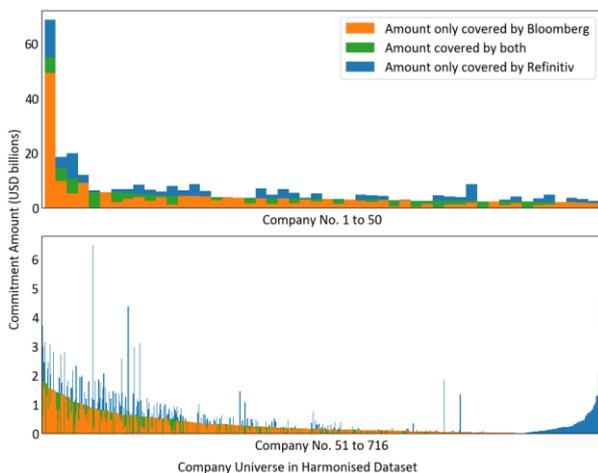
Figure 4 Data Source Coverage by Company (#Tranches)

8
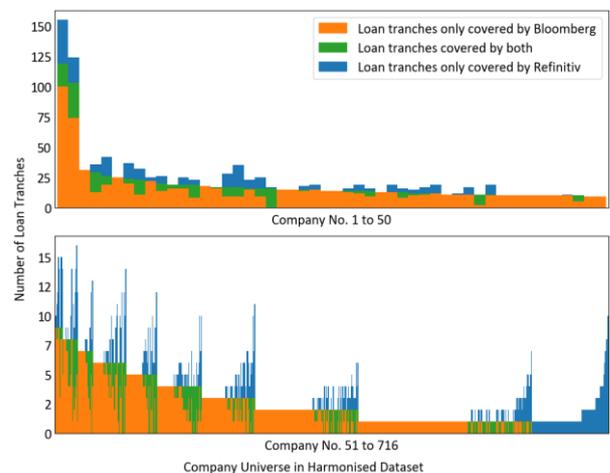
5. Lending Patterns

The total exposure of the reconstructed loan portfolios is USD 185.12 billion by January 2025. This reconstruction provides insights into lending activities across lenders, sectors, borrowers, and time horizons.

Concentration in Lenders

As shown in Figure 5, corporate loans exposures in Indonesia are concentrated among a few **large domestic commercial banks**. Bank Mandiri, Bank Negara Indonesia (BNI), Bank Central Asia (BCA), and Bank Rakyat Indonesia (BRI) together account for **33 percent** of exposures as of January 2025. This dominant pattern is consistent with OJK banking statistics, which report that these four institutions account for around 56 percent of total retail and corporate credit in the Indonesian banking system[4].

Other key lenders include **Japanese commercial banks** such as Sumitomo Mitsui Banking Corporation (SMBC), Mitsubishi UFJ Financial Group (MUFG), Mizuho Financial Group; **Singaporean commercial banks** such as Oversea-Chinese Banking Corporation (OCBC), Development Bank Singapore (DBS) and United Overseas Bank (UOB); **Development Finance Institutions (DFIs)** such as Japan Bank for International Cooperation (JBIC), Asian Development Bank (ADB), Korean Export-Import Bank (KEXIM) and China Development Bank (CDB); **other international banks** such as Commerce International Merchant Bankers (CIMB), Hongkong and Shanghai Banking Corporation (HSBC) and Bank of China (BoC); and **other domestic institutions** such as Sarana Multi Infrastruktur (SMI), Bank Syariah Indonesia (BSI), all Bank Pembangunan Daerah (BPDs) and Permata Bank.

Figure 5 Exposure by Lender, as of January 2025
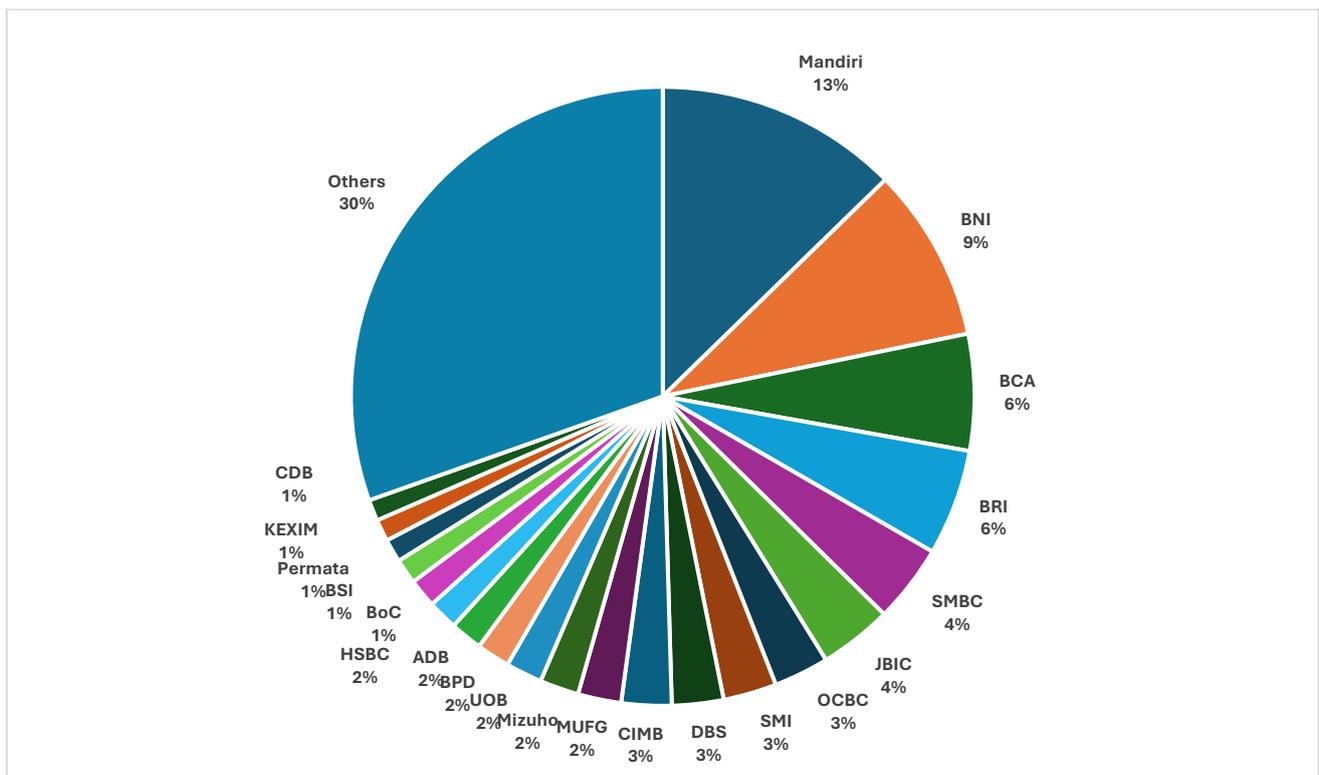
BPDs are regional development banks in Indonesia, each operating as a separate entity owned primarily by the provincial government. They have been aggregated in the analysis because their mandates and lending patterns are broadly similar, with a focus on supporting regional economic activity, local infrastructure, and SME financing.

The 17 banks after the 4 large domestic commercial banks account for 36 percent of the total exposure. The rest 31 percent is covered by other smaller local and international players.

The top 21 players in total account for approximately 70 percent of the total exposure. The dominance of these larger players poses more systematic risk to the financial system, especially in the climate risk perspective, where

transition or physical risk hazards occurring across multiple large players at the same time could contribute to joint distress within the financial system

Concentration in Emission-Intensive Sectors

As shown in Figure 6, credit exposures are concentrated over a few sectors, **electricity (24%), mining (22%), manufacturing (19%) and construction (13%)**, where large, syndicated borrowing are more common for infrastructure and production facilities. These sectors are also **emission-intensive** and therefore more susceptible to transition risks, which will be discussed in the next section of the report. Because climate risk distributes unevenly across sectors, such concentration adds to the systematic vulnerability of the financial system.

Figure 6 Exposure by Sector, as of January 2025
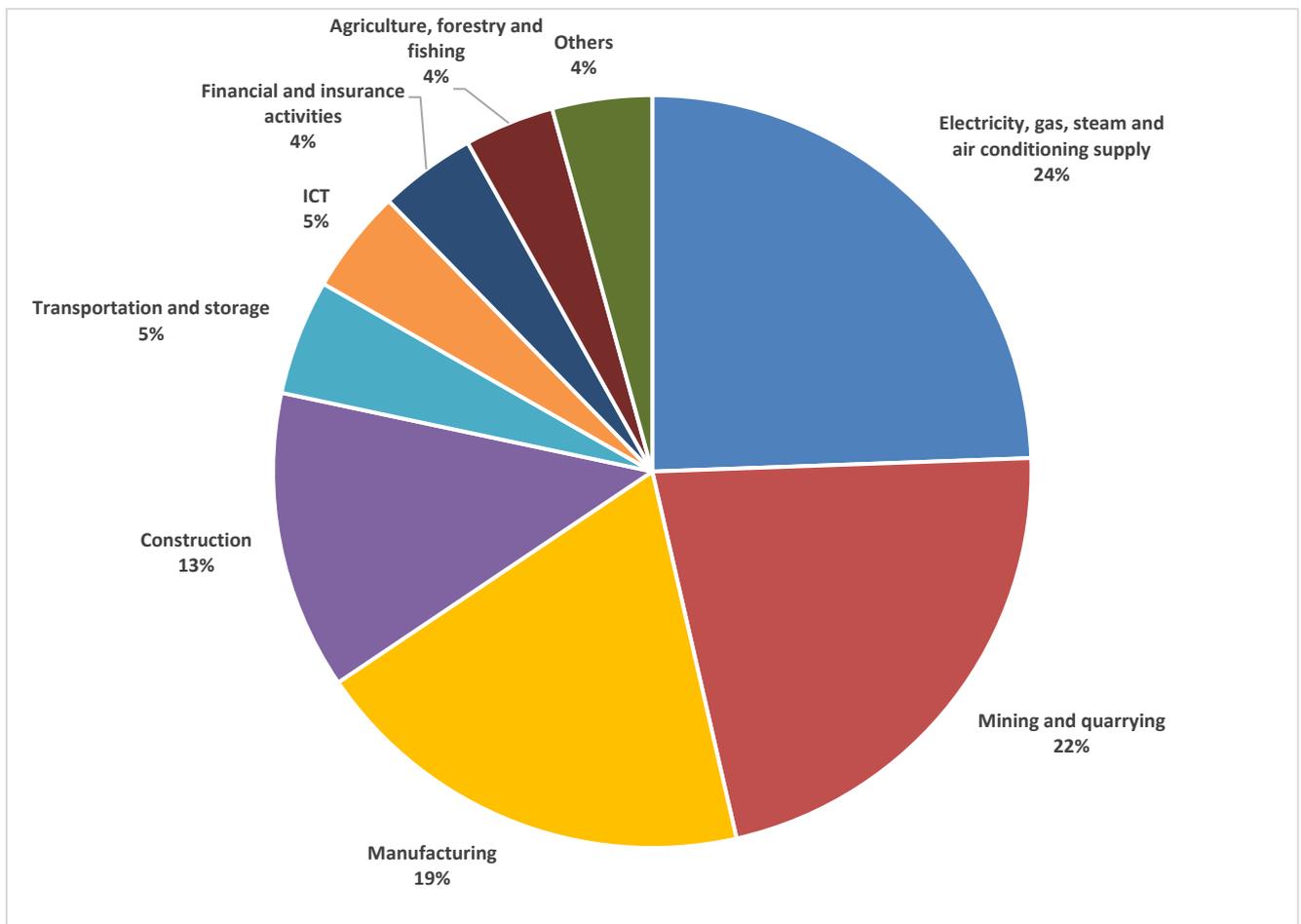
It is worth noting that the agriculture sector accounts for only 4 percent of total exposure in our reconstructed loan portfolio. This likely understates Indonesian banking sector's credit allocation to the agriculture sector, which typically represents a much larger share of bank lending in regulatory registers.[a] This discrepancy arises because the underlying data primarily consist of syndicated loans, which are larger in scale than typical corporate facilities. Agricultural credit is more commonly extended through bilateral lending to individual or small and medium-sized farmers, which is not typically captured in syndicated loan datasets.

Figure 7 Exposure Weighted Average Tenor by Sector
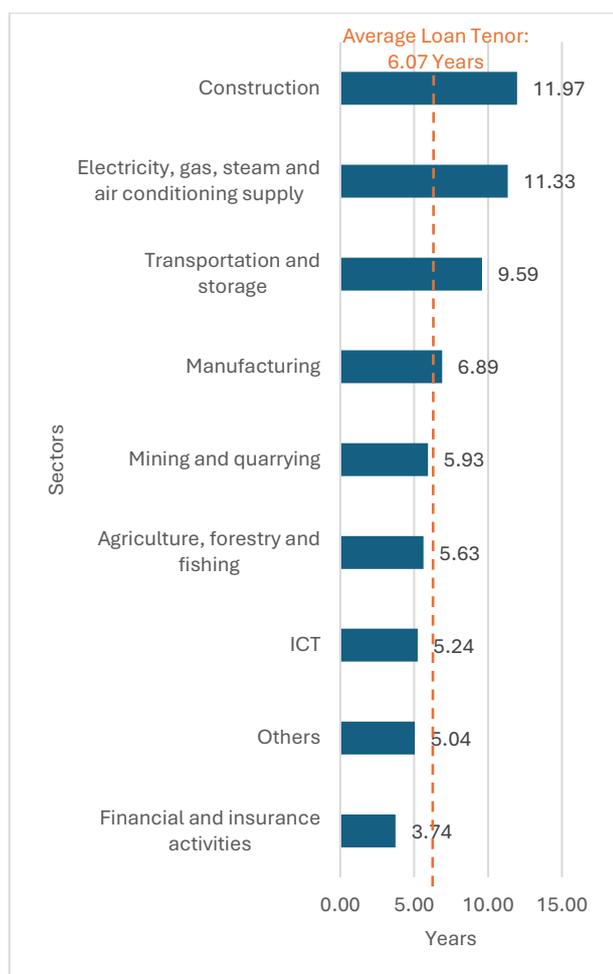
Long Maturities for Vulnerable Sectors

The sectors with the largest exposures also exhibit the longest average loan tenures, as shown in Figure 7. **Construction and electricity have tenures exceeding 11 years**, followed by transportation (10 years), manufacturing (7 years) and mining (6 years). Long maturities in these sectors effectively **lock in credit exposures over extended horizons**, limiting banks' ability to rebalance portfolios as transition pathways and physical hazards evolve. This prolonged exposure window increases vulnerability to both policy shifts and climate-related shocks.

By contrast, the financial sector shows the shortest average tenure at around 4 years. This aligns with its lending profile, which consists of a larger number of smaller, shorter-term facilities, as illustrated earlier in Figure 1 and Figure 2.

Concentration in Individual Obligors

In addition to lender and sector concentration, the Indonesian loan portfolio also exhibits significant concentration at the borrower level. Figure 8 shows **Perusahaan Listrik Negara (PLN)** as the largest borrower, accounting for approximately **6.8 percent of the total exposure** in January 2025. The electricity sector accounts for 27.8 percent of the exposure, reflecting its dominant role as the national utility responsible for Indonesia's generation, transmission, and electrification agenda.

Pertamina and its subsidiaries such as Pertamina Hulu Energi, Pertamina Balikpapan, and Pertamina International Shipping also feature prominently, consistent with their ongoing expansion strategy, which includes acquiring assets from multinational oil companies, developing new fields, upgrading refineries,

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[a] According to Bank Indonesia's Position of Rupiah and Foreign Currency Loans Provided by Commercial Banks and Rural Banks by Bank Group and Economic Sector (January 2025),

approximately 10% of total lending is directed to Agriculture, Forestry, and Fisheries; 22% to Manufacturing; and another 22% to Wholesale and Retail Trade, including vehicle repair.

expanding logistics infrastructure (storage, pipelines, shipping fleets) and investing in new energy businesses such as geothermal.

In infrastructure, Jasa Marga and its subsidiaries dominate toll road development and operations nationwide and therefore represent another substantial cluster of exposures. Mining and petrochemical firms, including Amman Mineral, Freeport, and major downstream producers, further contribute to borrower concentration.

Overall, **exposures are shaped by Indonesia's State-Owned Enterprises (SOE) and capital-intensive sectors.** The limited substitutability of these borrowers, given their strategic roles in electricity, energy, mining, and national infrastructure, further reduces banks' ability to rebalance exposures and increases the systematic risk from climate shocks.

Figure 8 Major Borrowers by Sector
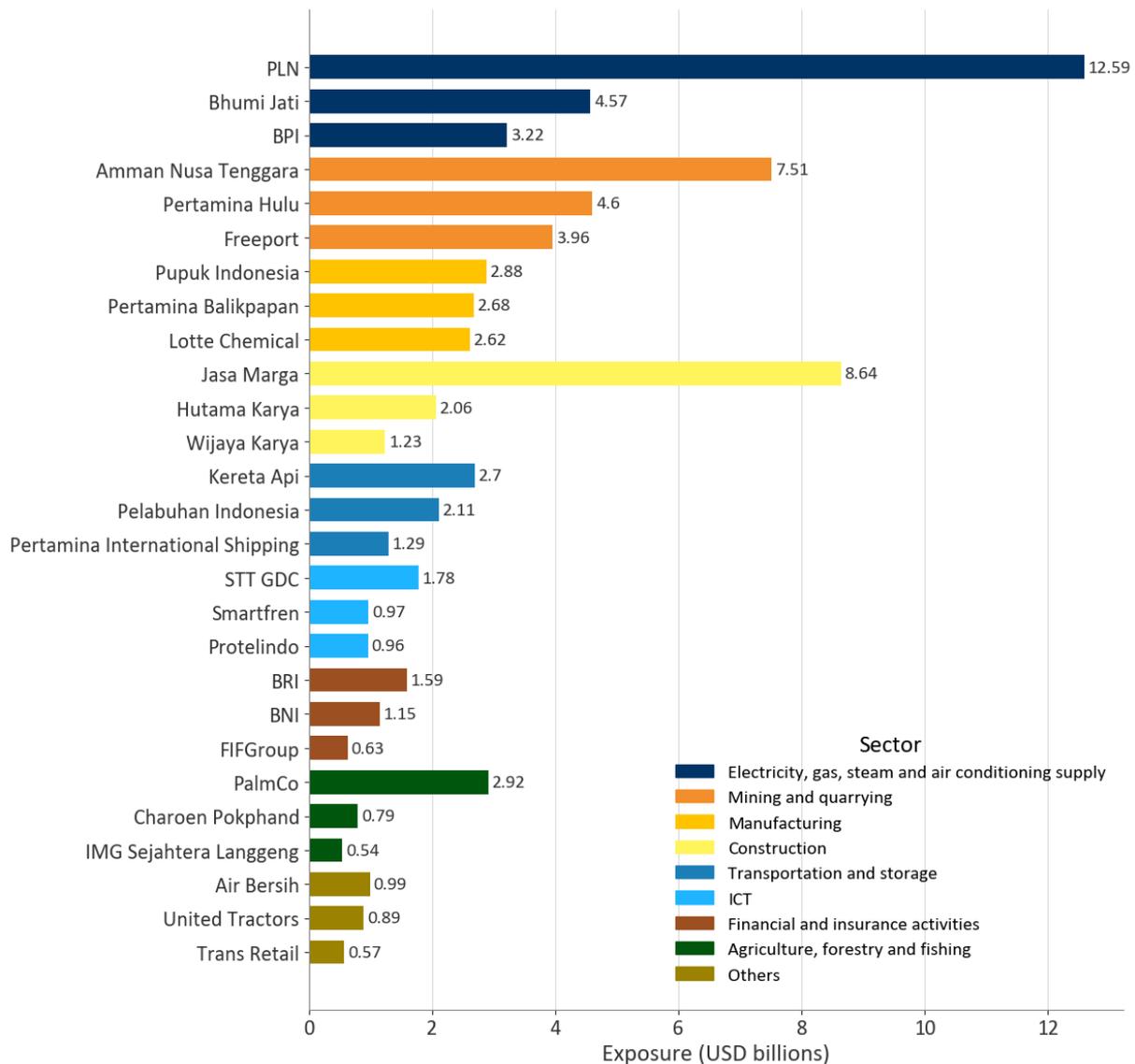
Portfolio Composition by Bank

As shown in Figure 9, **exposure compositions are broadly similar among the large domestic commercial banks** (Mandiri, BNI, BCA, BRI). Their portfolios show relatively balanced distribution across electricity, mining, manufacturing, and construction, reflecting their broader market presence and their ability to diversify across sectors. **Japanese banks** exhibit a higher concentration in the electricity sector, whereas **Singaporean banks** are more exposed to mining-related borrowers. **DFIs** tend to display similar portfolio profiles, typically concentrated in electricity, manufacturing, or construction. DFIs tend to provide financing in conjunction with specific projects; for example, CDB supported nickel-smelting and electricity-generation investments, while KEXIM financed petrochemical projects such as Lotte Chemical Indonesia.

Figure 9 Portfolio Composition by Bank
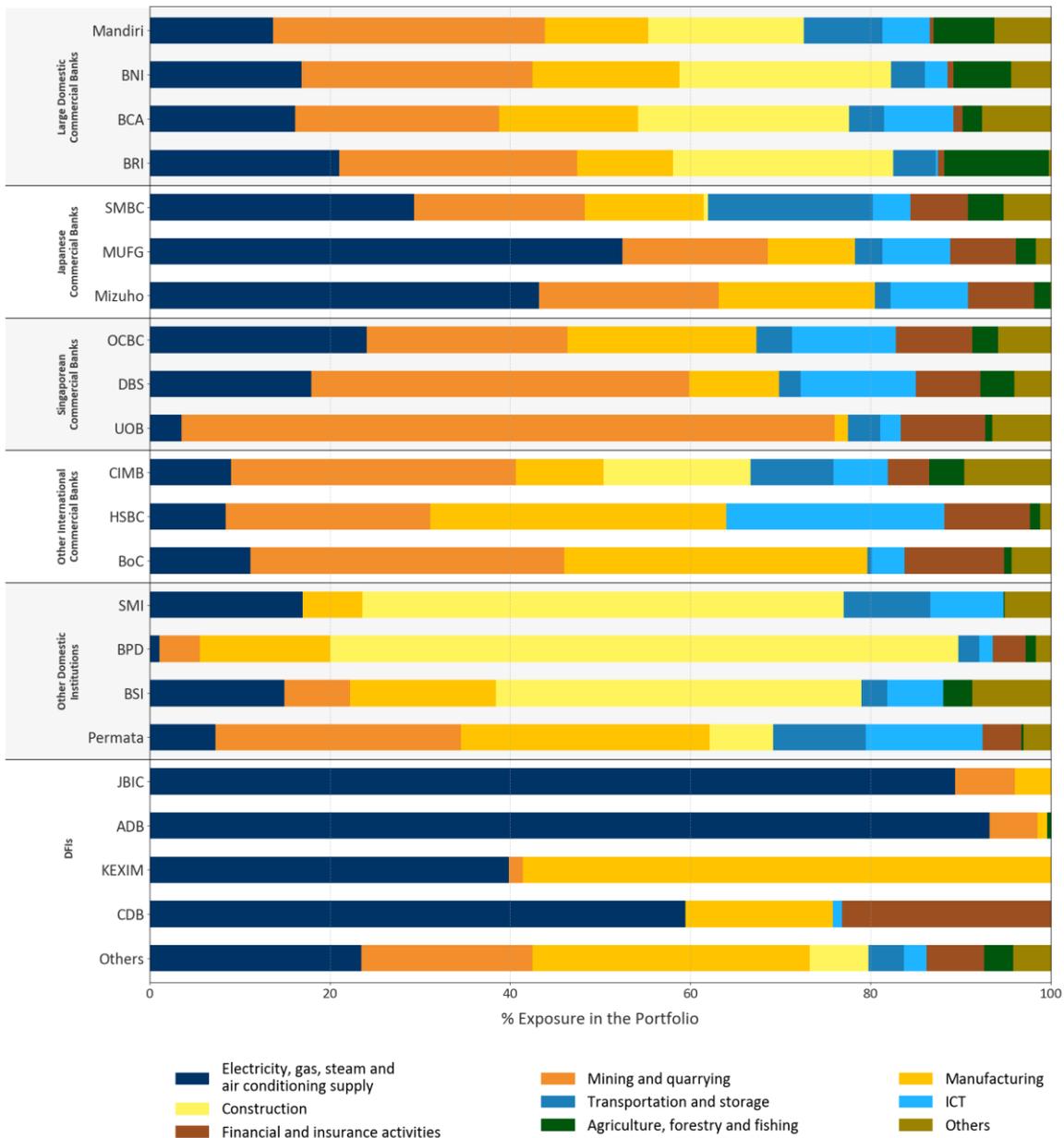
Trends in Sectoral Exposures Over Time

Figure 10 indicates **a general decline in newly issued loans to the electricity sector after 2016**. Over the same period, mining and manufacturing sectors increasing shares of new loan issuances, with **mining showing a notable rise** from 2021 onward, which will be examined later in the report. Lending to the financial sector also declines in our dataset after 2015. These shifts gradually influence the exposure composition, as new issuances are added to the amortised existing loans.

Figure 10 Issuance and Exposure Trend from 2015 to 2024
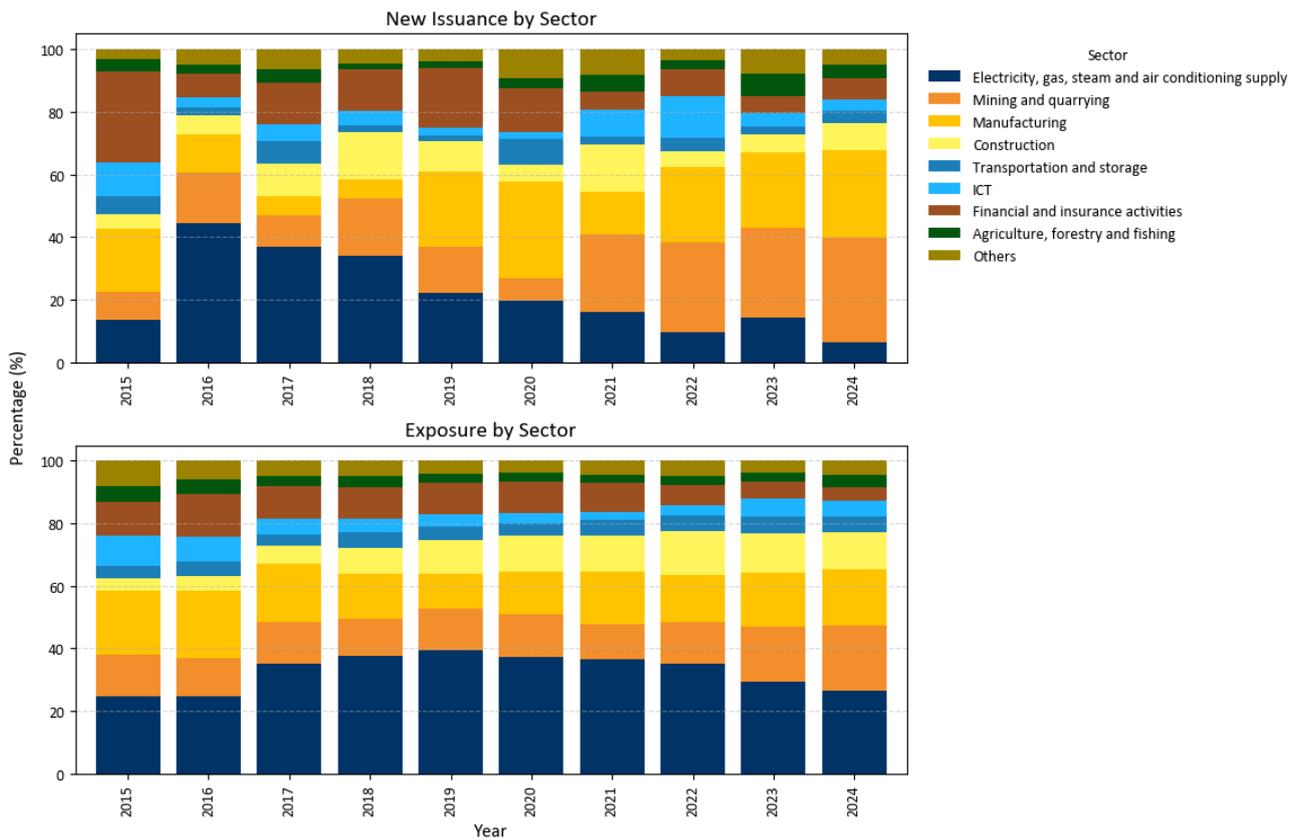
The trends across individual banks also differ over time. As shown in Figure 11, large domestic commercial banks display broadly similar patterns, with declining exposures to the electricity sector and a notable increase in mining-related exposures. They also maintain relatively higher shares of lending to construction companies, reflecting road development across the country.

Consistent with the earlier analyses, **Singaporean banks are more exposed to the mining sector**, particularly with UOB's exposure increasing significantly in recent years. In 2025, UOB's mining exposure is contributed mainly by credits to Amman Mineral (gold and copper), Pertamina Hulu Energi (oil and gas), and Trimegah Bangun Persada (nickel). **Japanese banks, in contrast, maintain a comparatively high exposure to the electricity sector**, close to 50 percent of their portfolio. Their mining exposures remain relatively stable over the horizon.

Figure 11 Exposure Trend for Selected Banks
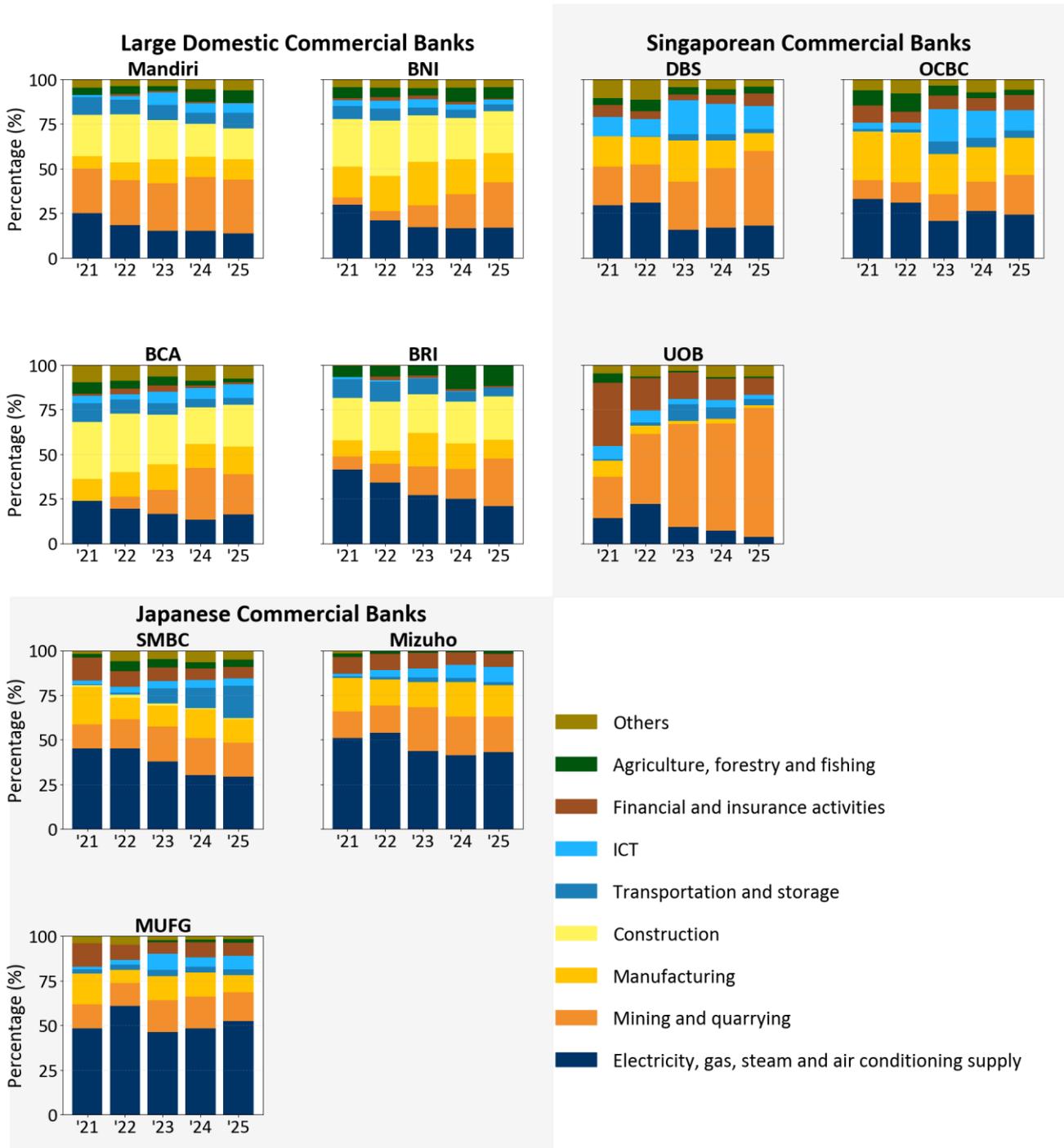
Loan Issuance to Mining and Downstream Processing Industries

Over the past five years, borrowing by mining industries and their downstream smelting and refining activities has increased. As shown in Figure 12, loan issuance to these segments rises notably from 2022 onward. Nickel-related borrowing, which was minimal before 2019, begins to expand following policy changes under ESDM Ministerial Regulation No. 11 of 2019, which accelerated the nickel ore export ban and supported domestic processing. The increase becomes more pronounced after the post-COVID recovery. The surge in smelter projects increased upstream demand for more nickel ore, which explains **the increase in borrowing from the nickel mining sector**. By 2023, newly issued loans to nickel-related mining and smelting in our dataset exceed those to coal mining. Credits to nickel smelting was directly boosted by the regulation. In 2025Q1, lending to nickel smelting is comparable in scale to lending for nickel mining. New loans to gold and copper activities, as well as to oil and gas extraction and refining, also remain sizable over the period. There is no data reported in 2025Q1 for coal mining yet in our sample.

Figure 12 Loan Issuance by Mining Type
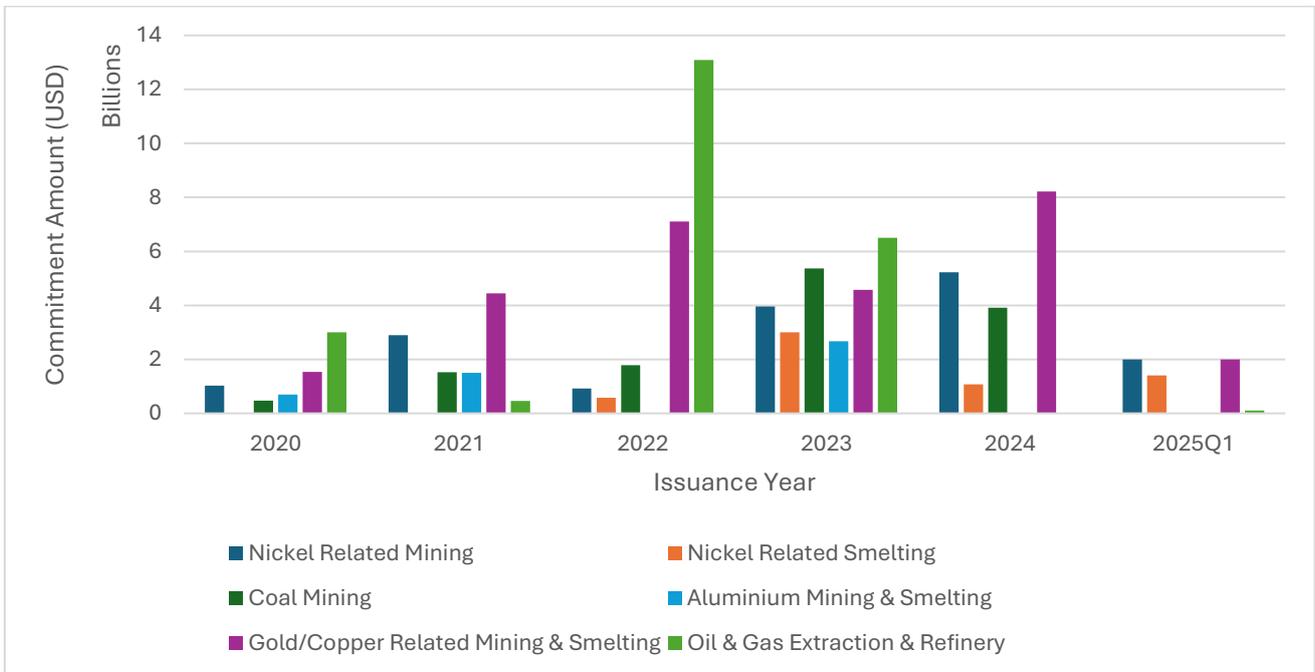
A closer examination of participating lenders reveals a distinct contrast between financing patterns in the nickel and coal segments. As shown in Figure 13, Nickel-related mining activities are supported by a broad and **internationally diversified group of lenders**, including Singaporean banks and several large Chinese institutions. As shown in Figure 14, the expansion of nickel smelting is accompanied by steady involvement from domestic banks, while the sharp peaks in issuance reflect lending from Chinese banks. The grey "Others" segment in 2023, for example, includes more than USD 2 billion in credits from CITIC Bank, Agricultural Bank of China, and Shanghai Pudong Development Bank, in addition to lending from Bank of China and CDB, labelled in dark and light blue respectively.

This pattern aligns with the structure of Indonesia's nickel downstream industry, where Chinese firms have made substantial investments

in smelters and processing parks, and where affiliated Chinese banks often provide project or corporate financing.

Figure 13 Credits Issued to Nickel-Related Mining

Figure 14 Credits Issued to Nickel-Related Smelting
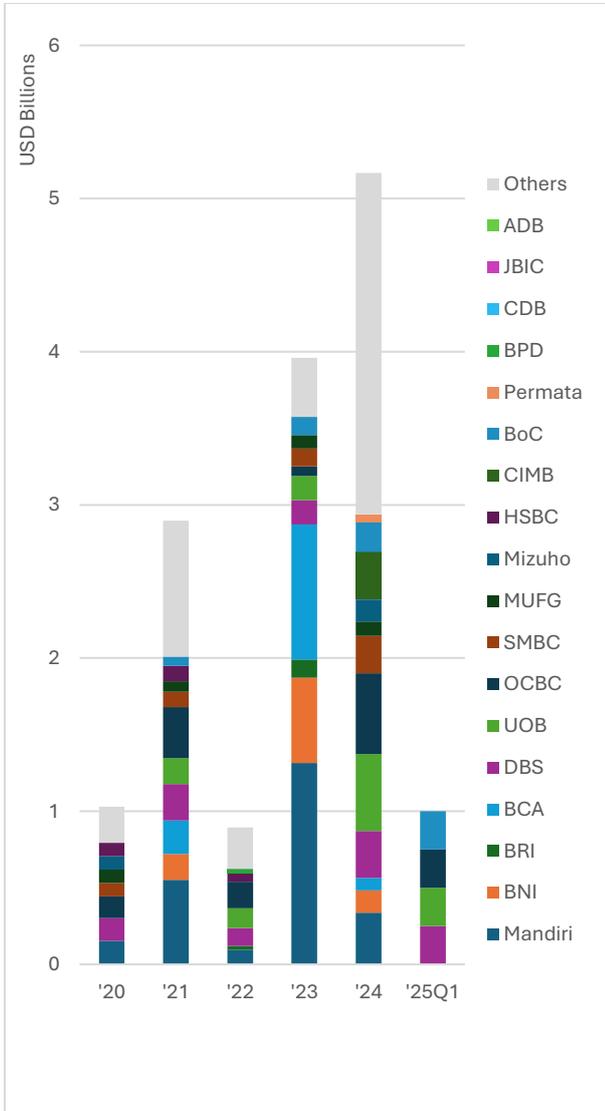
As shown in Figure 15, credits to the coal-mining sector are disbursed by **a narrower set of lenders, primarily by large domestic commercial banks**. This reflects the predominantly local ownership structure of Indonesia's coal industry and the longstanding credit relationships between domestic banks and coal producers. State-owned banks also often face political pressures to finance projects aligned with government objectives. This could also be partially explained by the withdrawal of many international banks from

coal-related financing, leaving domestic institutions as the primary lenders to the sector.

Overall, nickel-related activities attract a wider and more international set of lenders due to their integration into global industrial and battery-material value chains, while coal financing remains concentrated among domestic banks amid declining international appetite for coal exposure.

Figure 15 Credits Issued to Coal Mining

adjust their portfolios in response to evolving climate risks.

Differences across lender groups are notable. Large domestic commercial banks maintain relatively diversified sectoral portfolios, while Japanese banks retain a significant share of exposure to the electricity sector. Singaporean banks show greater participation in mining-related activities. DFIs exhibit concentrated exposure patterns tied to project-based mandates. These distinctions mean that transition and physical risks will not be evenly distributed across the banking system.

Loan-issuance trends further shape the exposure profile, with credits for mining sector increasing in proportion for most of the banks. Nickel-related mining and downstream processing have attracted increasing financing, especially after 2022, with participation from both domestic and international lenders, particularly China. In contrast, coal-mining finance remains dominated by domestic banks, reflecting political pressure, local ownership structures and reduced foreign participation.

The reconstructed loan portfolio – combining Bloomberg and Refinitiv data sources – provides a critical foundation for the physical and transition risk analysis in the next two sections.

6. Discussions

The reconstructed portfolio reveals a high degree of concentration within lenders, borrowers, and sectors. A small number of large domestic commercial banks account for a substantial share of total credit. Exposures from fossil-intensive sectors are also concentrated in a few major borrowers, many of which are state-owned enterprises (SOEs) operating electricity, mining and infrastructure sectors. These capital-intensive sectors typically have longer loan maturities, limiting the speed at which banks can

Chapter III

Transition Risk

III.   Transition Risk

Transition risk refers to the financial and operational consequences that emerge when economies shift toward lower-carbon systems. These risks arise from changes in policy, technology, and market behaviour that alter the viability, cost structure, or competitiveness of carbon-intensive activities.[5]

In many jurisdictions, transition risk is triggered by regulatory tightening such as carbon pricing, emission caps, or fossil fuel phase-out signals, combined with fast-paced improvements in cleaner technologies.[6] All these channels could lead to decline in revenue, stranded asset risk, higher financing costs, or margin compression, especially for energy-intensive industries.

Indonesia's Resource-Driven Economy

In Indonesia, however, the structure and speed of transition risk differ materially from this global pattern. The country's policy framework, spans from Nationally Determined Contribution (NDC), electricity generation business plan (RUPTL), to long-term national energy policy (RUKN). From macro to micro policy framework, all of them collectively reinforce a gradual, long-horizon transition pathway where some high emission sectors such as electricity, manufacturing, transportation, and mining continue to play central roles well into the 2030s and early 2040s, complemented by gradual renewable expansion and delayed large-scale storage deployment.

The structural orientation is also reflected on the financing side. International mechanisms such as the Just Energy Transition Partnership (JETP) and domestic instruments like the newly established sovereign wealth fund, Danantara operate within the same long-term orientation. JETP provides additional financing, though its disbursement timeline and debt-oriented composition suggest that near-term decarbonisation would occur slower than expected (See Appendix 3).

Danantara, while potentially able to fill financing gaps, does not yet carry an explicit decarbonisation mandate.[7]

While Indonesia does not employ rapid-tightening tools such as explicit coal phase-out mandates, carbon pricing, or accelerated technology seen in other jurisdictions like in Germany[8], France, and Canada[9], this does not eliminate transition pressures. Even with a gradual domestic transition pathway, firms in hard-to-abate sectors like steel, cement, refinery, mining, and heavy transport remain exposed to transition risk because export demand, technology costs, and international standards are changing rapidly. In practice, global shifts in carbon pricing, buyer requirements, and cleaner-tech competitiveness present potentially binding constraints these sectors must respond to.

These global market signals have the potential to disrupt Indonesian firms through commercial and financial channels. As overseas customers tilt toward low-carbon materials and supply chains, high-emissions producers in Indonesia risk losing market share or facing price discounts, with cross-border carbon taxation mechanisms (such as the EU's Carbon Border Adjustment Mechanism (CBAM)) adding direct cost penalties. At the same time, international asset managers, lenders, and insurers are repricing loans and assets around emissions intensity, making capital more expensive or conditional on decarbonisation commitments and plans. These potentially result in a market-driven squeeze on margins and asset valuations that precedes, and often forces, on-the-ground operational changes.

A robust assessment therefore needs to treat transition risk in Indonesia's hard-to-abate sectors as a combination of domestic policy response and external market acceleration. When global decarbonisation benchmarks tighten faster than domestic rules, firms could access to

export markets, carbon cost pass-through, and higher risk premia, leading to revenue, cost, and refinancing shocks, even in the absence of more intensive domestic enforcement efforts. The scale of risk then depends on whether Indonesia's policy framework and institutions enable credible, timely adjustments. Failure to do so risks locking scarce capital into emissions-intensive pathways that face rising risk exposures of cross-border penalties and wider financing spreads, increasing the likelihood of stranded assets and credit deterioration that can culminate in corporate defaults.

1. National Policy Overview: A Gradual Transition Pathway Anchored by Economic Realities

Indonesia's climate and energy policies converges towards economic growth, energy affordability, and system reliability remains top priorities. Therefore, decarbonisation will progress in a measured, multi-decade manner. Its NDC reflects this posture. Although the NDC formalises the direction of emissions reduction, it does not include any commitments to near-term regulatory tightening. Instead, it frames the transition as a process that must not compromise growth or impose sudden cost burdens on the energy system or the broader economy. These trends are not unique to Indonesia, as they are similar to NDCs of other developing countries like Vietnam, Malaysia, [10] and South Africa. [11] As a result, near-term policy risks stemming from the NDC are limited.

Indonesia's long term electricity strategy is operationalised in the RUPTL 2025–2034. The plan sets out a large expansion of energy capacity, with a total of 69.5 GW of new capacity, including 42.6 GW of renewables (about 61 percent) and 10.3 GW of storage. However, even with a sound plan that addresses resource–demand mismatches and grid constraints, the required investment still far exceeds what PLN, a

monopolistic state-owned enterprise responsible for national electricity generation, can finance on its own. Realization of this plan will hinge on large-scale participation from independent electricity producers (IPPs) to bridge the financing gap. [12] As a result, fossil fuels remain the backbone of the electricity sector throughout the coming decade, with renewables scaling gradually alongside system upgrades, subject to private investment feasibility. The RUPTL thus mirrors the NDC's economic stance, transition where feasible.

The energy transition policy orientation strategy under RUKN 2025–2060 completes the narrative. It charts a system in which coal remains present well into the 2030s, gas expands as balancing capacity, while nuclear and energy storage only enter meaningfully after 2040. [13] Together, the NDC, RUPTL, and RUKN describe a sequential, reliability-centred transition pathway rather than an accelerated decarbonisation strategy. (See Appendix 2).

For financial institutions, the alignment across the NDC, RUPTL, and RUKN indicates that domestic transition risks will emerge gradually rather than through abrupt policy tightening. With policy signals stable and long dated, the decisive factor becomes not regulation but the financial capacity to fund the transition itself. Indonesia's ability to shift from fossil dependence toward a more diversified energy system will hinge on the volume, concessionality, and timing of capital available for system upgrades, renewable expansion, and grid reinforcement.

2. Transition Financing Vehicles

Understanding Indonesia's transition-financing vehicles is essential for assessing transition risk, because the structure and timing of available capital fundamentally shape how quickly and affordably the energy system can shift away from fossil fuels.

Capital Mobilisation for Gradual Transition

Indonesia's transition financing ecosystem consists of multiple domestic and international mechanisms ranging from sovereign bond, multilateral development bank (MDB) lending, and energy-sector subsidies to IPP financing arrangements and blended-finance initiatives.[14] Within this broader landscape, two institutional instruments emerge as the most prominent in terms of policy visibility, namely the JETP and Danantara, the newly established sovereign investment vehicle. JETP and Danantara together illustrate how Indonesia is orchestrating capital mobilisation beyond the state budget. JETP anchors international concessional finance commitments, while Danantara operationalises both domestic and international capital through a market-based financing platform.

JETP: International Leverage to Facilitate Transition Acceleration

The Just Energy Transition Partnership (JETP), announced during Indonesia's G20 Presidency in November 2022, aims to mobilise international capital for the country's electricity-sector transition. Its Comprehensive Investment and Policy Plan (CIPP), released by the JETP Secretariat in November 2023, outlines priority investments in transmission upgrades, dispatchable renewables, variable renewable energy (VRE) acceleration, and coal plant repurposing.

While the JETP package does mobilise a sizeable 21.4 billion USD of international concessional financing, the overall commitment remains predominantly debt based. Commercial loans account for roughly 46 percent, concessional loans about 32 percent, and non-concessional loans seven percent. Guarantee account for 10 percent, while equity and guarantee altogether collectively contribute only about five percent.[15] Although the concessional–commercial mix in the JETP is typical for emerging-market transition packages[16], its implications differ in Indonesia because the principal implementing entity, PLN, operates within a tariff structure that prioritises affordability and is supported by subsidies and government compensation rather than its market cost. Retail electricity prices cannot be freely adjusted to recover rising capital or system-integration costs, and gaps between the cost of supply and regulated tariffs are routinely covered through fiscal transfers. At the same time, PLN must honour long-term take-or-pay under power-purchase agreements (PPAs) that guarantee full cost recovery for IPPs, ensuring stable returns for private generators even when PLN's own financial position is under pressure. PLN large borrowing restrains its ability to take on more debt, even concessional financing.

Considering these constraints, the concessional terms offered under JETP provide only mild relief to Indonesia by lowering the cost of capital marginally. Preliminary assessments indicate that such support is unlikely to effectively overcome deeper structural limitations. Legacy commitments to fossil-fuel, tariff-setting restrictions, and unpriced system-integration costs associated with higher renewable penetration continue to shape project bankability in the sector. As a result, the affordability gains from concessional financing remain inherently negligible, particularly in the absence of regulatory and sectoral reforms to strengthen cost-recovery mechanisms and clarify risk-sharing arrangements within the electricity system.

Limited progress to date reflects these constraints. Compared to the overall commitment, as of September 2025, only USD 2.85 billion has been approved across a limited set of programmes and projects, primarily focused on early-stage renewable energy, geothermal development, transmission strengthening, and selected de-dieselisation

initiatives. Much of the broader JETP portfolio remains in preparatory or negotiation stages, and pipeline commitments of roughly USD 5.5–6.2 billion have yet to be translated into disbursements.

In this context, JETP offers valuable international leverage but has not yet delivered a level of affordability or certainty sufficient to drive a rapid transition. Its impact will depend on whether financial support is paired with regulatory and sectoral reforms that address Indonesia's underlying cost structure and system architecture (See Appendix 3).

Danantara: Domestic Capital Mobilisation with Broad Mandate

Danantara is Indonesia's new sovereign investment vehicle aimed at consolidating state-owned assets and strengthening domestic capital formation. While it can play a complementary role to JETP in sectors such as energy infrastructure, industrial development, and mineral down-streaming, its primary mandate is oriented toward economic transformation and value creation.[17]

Unlike other sovereign wealth funds with explicit energy transition objectives, such as Singapore's Temasek[18], Danantara is not yet aligned with sustainable finance taxonomy, transition pathway, or sector-level decarbonisation roadmap. Its investment decisions prioritise strategic sectors with high multiplier effects, which may include industrial projects with substantial fossil-fuel dependencies. Governance arrangements anchored within state entities further emphasise policy coordination over transition objectives.

Thus, while Danantara has the potential to mobilise domestic capital towards transition at scale, its initial direction does not alter the macro trajectory of Indonesia's energy transition. It supports growth and industrial upgrading consistent with national policy priorities but does not impose transition-aligned conditions on fossil-intensive sectors.

All things considered, Indonesia's transition financing vehicles expand capital access but do not alter the overall pace or direction of the transition. As previously discussed, Indonesia's domestic policies impact remains minimal to decarbonisation, with transition risks largely driven by factors outside domestic regulation.

3. Sectoral Focus

Why Some Sectors Matter More

Indonesia's transition-risk exposure is anchored in the structure of its energy system. The RUKN outlines a configuration in which fossil-fuel capacity, particularly coal and gas, remains essential for maintaining power-system reliability and supplying the continuous, high-temperature energy needed by industrial users.[b] This system-wide dependence shapes the operating environment of energy-intensive industries and limits the speed at which large-scale decarbonisation can occur in the near to medium term.

Within this context, coal, oil and gas, electricity, and nickel processing emerge as the sectors most exposed to transition pressures. Their production processes require stable, high-heat inputs typically met through coal-fired captive plants, diesel generators, or gas turbines. Analyses of JETP Database in 2025 indicate that captive power capacity has doubled since 2019, with more than 95 percent of new additions supplied by coal and the nickel-processing segment contributing around 85 percent of total

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[b] See Appendix on RUPTL and RUKN.

expansion, evidence of deep fossil lock-in at the facility level.[19]

Other emission-intensive industries such as cement or steel remain significant in absolute terms, although they are not the focus of current industrial-policy expansion. In contrast, nickel processing, oil and gas, and coal-linked industries are explicitly prioritised through recent directives.[20] These policy developments aim to advance industrial and energy-security objectives but, consequently, also expand activity in sectors that are structurally energy-intensive and operationally rigid.

These structural and operational characteristics translate directly into financial-system relevance. The same sectors account for a sizeable share of capital formation and feature prominently in domestic commercial loan books, magnifying the channels through which transition shocks may propagate.[c] Consistent with risk-transmission patterns highlighted in Network for Greening the Financial System (NGFS) and IMF financial-stability assessments, the scale and fossil dependency of these sectors making them especially sensitive to external transition pressures, including tightening international carbon border measures, emerging global product standards, shifts in technology competitiveness, and the market revaluation of carbon-intensive assets. These features collectively explain why transition pressures are most likely to crystallise in these segments and why they form the core of Indonesia's transition-risk assessment.

To understand how these sector-level exposures manifest at the firm level, the next section examines corporate transition disclosures across

coal, oil and gas, electricity, and nickel producers. The review does not evaluate credibility or performance. Instead, it maps how companies articulate transition-related intentions within the constraints of Indonesia's policy trajectory and energy-system configuration, and identifies where firm-level positioning aligns with, or diverges from the structural dependencies outlined above.

4. Assessing Company Level Transition

Evaluating a company's planned transition towards low carbon operations is a multi-faceted exercise. Corporate transition plans should not focus merely on setting ambitious targets and goals to arrive at net zero but should also ensure that there is a feasible plan in place to achieve them. In addition, it is important that the right governance structures and verification measures are in place to ensure that reported data on the progress in transitioning towards net zero is trustworthy. The adoption of internationally recognized frameworks and validation and verification bodies would provide confidence to investors and stakeholders.

Assessing the Transition

To assess corporate transition plans, the Sustainable and Green Finance Institute (SGFIN) developed the Transition Readiness Scorecard (TRS). The TRS considers both essential actions that are critical for companies in reaching net zero and supportive initiatives that significantly aid companies in transitioning towards net zero. We assess readiness through indicators capturing governance, performance, strategic alignment, and disclosure practices. These indicators are categorized into six pillars presented in Table 1, providing a structured basis for comparing each

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[c] Bank Indonesia's Outstanding Loan Statistics (rupiah and foreign currency) show that approximately 32% of total lending is allocated to Mining and Quarrying, Manufacturing Industry, and Electricity and Gas Supply. While these categories are broader than the specific subsectors analysed in this study, they provide an indicative measure of the financial-system exposure concentrated in energy-intensive and fossil-dependent activities.

company's progress and identifying where corporate transition efforts are most and least developed.

We allocate different weightage for each indicator to reflect its contribution to each company's transition towards net zero, with those more critical assigned higher weightages and those that are primarily supportive of more critical indicators assigned lower weightages.

For example, setting a defined net zero target year provides a clear long-term direction for the company and guides relevant corporate policy formulation, resulting in a heavier weightage for this indicator.

In contrast, Carbon Disclosure Project (CDP) participation, while encouraged, is largely a disclosure mechanism and does not directly influence the effectiveness of a company's decarbonisation efforts. Thus, it is assigned a lower weightage.

Pillar "Target Setting & Sectoral Alignment"

Net Zero Target

Having a net zero target provides a definite pathway towards low carbon operations that the company is working towards. Concurrently it provides a clear long-term direction that steers policies and initiatives towards this goal.

Net Zero Interim Target

A net zero interim target provides an explicit milestone to track the company's progress in its transition towards net zero. It provides a clear benchmark to evaluate near-term actions, and aids in keeping the company accountable to its long-term goal.

Table 1 Transition Readiness Scorecard (TRS)

Pillar	Indicator	Weightage
Target Setting & Sectoral Alignment	Net Zero Target	10.0%
	Net Zero Interim Target	5.0%
	SBTi Validation	10.0%
	Sectoral Pathway Alignment	5.0%
Emission Coverage & Reduction Strategy	Scope 1 & Scope 2 Reporting	10.0%
	Scope 3 Reporting	10.0%
	Emissions Reduction Strategies	5.0%
	Use of Carbon Offset	5.0%
Governance & Accountability	Board-level Oversight & Dedicated Sustainability Teams	7.5%
	Executive Compensation Tied to Climate Goals	7.5%
Financial Integration	Capital Allocation	5.0%
Disclosure Transparency	GRI-aligned Reporting	5.0%
	TCFD-aligned Reporting	5.0%
	CDP Participation	5.0%
Climate Risk Analysis	Climate Risk Scenarios	5.0%

SBTi Validation

Receiving validation of the company targets by the SBTi (Science Based Targets initiative) is essential to corporate transition since it ensures that the targets are not only realistic and viable but also aligned with scientific climate expectations. This increases the credibility of the company's goals and minimizes concerns of greenwashing accusations in the future.

Sectoral Pathway Alignment

It is important that a company's net zero commitment is in alignment with national and / or international goals. Moreover, as some companies operate across multiple sectors and face sector-specific issues and challenges, it is essential to contextualize their transition plans to the relevant sectors whenever possible. This would also in turn allow comparisons with other companies that are within the same sector.

Pillar "Emission Coverage & Reduction Strategy"

Scope 1 & Scope 2 Reporting

Scope 1 and Scope 2 greenhouse gas (GHG) emission categories reflect emissions that are critical to a company's ongoing operations, with Scope 1 reflecting direct emissions and Scope 2 capturing indirect emissions, i.e., from electricity usage. These are emissions that are largely within the company's control and therefore provides critical indicators of whether the company is making any progress towards decarbonisation.

Scope 3 Reporting

Tracking and reporting scope 3 emissions is a critical step in assessing whether the company's supply chain can meet its net zero commitment. Scope 3 emissions typically make up a large fraction of the total emissions generated by a company's operations. The consideration of scope 3 emissions reflects the company's understanding that its net zero commitment should covers all parts of its operations.

Reporting Scope 3 is also beneficial in setting guardrails against companies outsourcing their decarbonisation responsibilities to third parties, particularly when its Scopes 1 & 2 emissions have been reduced.

Emissions Reduction Strategies

The disclosure of emissions reduction strategies would enable stakeholders and shareholders to assess whether these strategies are sufficiently detailed and operationally viable. These would also allow stakeholders and shareholders to assess if the firm's operations are veering off course relative to previously disclosed strategies.

Ultimately, this would enhance the credibility of the targets set by the firm beyond merely fulfilling regulations.

Use of Carbon Offsets

The use of carbon credit offsets is a beneficial component for organizations working towards net-zero goals. When an organization declares to what extent carbon credits are used, it allows stakeholders to evaluate whether the company solely relies on these offsets to achieve its decarbonisation goals. Doing so would amount to greenwashing, essentially paying to continue operations as per business as usual without making meaningful emissions reductions.

Pillar "Governance and Accountability"

Board-Level Oversight & Dedicated Sustainability Teams

Adopting board-level oversight and dedicated sustainability teams in the organization's structure would facilitate the company's sustainability efforts.

Equipping these relevant individuals with the necessary training and skillset to develop strategies and appropriate contingency plans would be critical to achieving the company's sustainability goals.

Executive Compensation Tied to Climate Goals

Linking compensation and key performance indicators of senior corporate executives and board members to the company's climate goals would ensure their personal interest and motivation in the success of the transition plan towards net-zero.

Pillar "Financial Integration"
Capital Allocation toward Climate Goals

With capital allocation towards strategies relevant to climate goals, the company shows its commitment to providing necessary resources and financing to achieve its targets. This would provide some assurance that its disclosed strategies and initiatives are viable in the long term and would have sufficient resources for its execution.

Pillar "Disclosure Transparency"
GRI-Aligned Reporting, TCFD-Aligned Reporting, CDP Participation

Adopting sustainability reporting frameworks (e.g., TCFD, GRI) and participating in the Carbon Disclosure Project (CDP) would enhance confidence in the accuracy of the firm's reported emissions data and the progress of its sustainability initiatives. As these frameworks are internationally recognized, investors and stakeholders can be assured that the firm's reporting is credible and consistent.

Pillar "Climate Risk Analysis"
Climate Risk Scenarios

The consideration of climate risk scenarios facilitates long-term corporate planning, including appropriate mitigation actions that would aid the company in reducing these risk exposures. It would also help to identify future opportunities that these scenarios might present.

With these indicators established, the analysis now turns to how the company-level findings translate into the overall evaluation and result.

Evaluations of Transition Readiness

From the results shown in Table 2, there is a general trend of improvement for the transition plans for the companies assessed. The most general improvement is observed in the "Target Setting & Sectoral Alignment" pillar (Refer to Appendix 4). The "Financial Integration" pillar exhibited minimal improvement over the years, as most companies have remained largely stagnant in its fulfilment rates. Somewhat surprisingly, companies in the Oil & Gas sector seem to perform better compared to other firms in this sample. Performances from companies in other sectors are mixed and do not exhibit a widespread trend of good or poor performance.

Comparison with Transition Pathway Initiative Management Quality Evaluation

For further assurance, the companies evaluated using the TRS were also assessed using the Transition Pathway Initiative (TPI) Management Quality Evaluation framework. This framework is designed to provide independent, transparent, and high-quality assessments of a company's journey towards net zero.

The detailed results and their associated descriptions are provided in the Appendix 4. As shown in Table 2, the best-performing sector is Oil and Gas. This is consistent with the results of the TPI evaluation, where Pertamina and Medco, both from the Oil and Gas sector are the only two companies among the five evaluated that meet the thresholds up to Level 3, where TPI defined it as integrating transition into operational decision-making.

Based on assessments from both the TRS and TPI frameworks, while overall corporate transition readiness is improving, yet this progress has not translated into meaningful financial commitment or integration, resulting in limited near-term operational and financial impacts.

Table 2 Evaluation of Indonesian Companies with the TRS

Company	Sector	Total Score			
		2021	2022	2023	2024
PT Bumi Resources Tbk	Mining - Coal	22.5%	⇄22.5%	⇄22.5%	↗30.0%
PT Adaro Energy Tbk	Mining - Coal	20.0%	↗40.0%	↗50.0%	↘42.5%
PT Bayan Resources Tbk	Mining - Coal	22.5%	↗35.0%	↘22.5%	↘20.0%
PT Indo Tambangraya Megah	Mining - Coal	40.0%	⇄40.0%	⇄40.0%	↗52.5%
PT Bukit Asam Tbk	Mining – Coal	45.0%	↗55.0%	↘52.5%	↗57.5%
PT Vale Indonesia Tbk	Mining – Nickel	40.0%	↗42.5%	↘37.5%	↗47.5%
PT Aneka Tambang Tbk	Mining – Nickel, Gold, Bauxite	30.0%	↗37.5%	↗60.0%	↗57.5%
PT TBS Energi Utama Tbk	Mining – Coal	30.0%	↗45.0%	⇄45.0%	↗57.5%
PT United Tractors Tbk	Mining – Misc	20.0%	⇄20.0%	↗50.0%	↗57.5%
Perusahaan Listrik Negara (PLN)	Electricity Generation	25.0%	↗42.5%	↗60.0%	↗67.5%
Medco Energi	Oil & Gas	52.5%	↗62.5%	⇄62.5%	↗75.0%
Pertamina	Oil & Gas	52.5%	↗72.5%	⇄72.5%	↘62.5%
PT Cirebon Electric Power	Utilities	10.0%	⇄10.0%	⇄10.0%	⇄10.0%
PT Cikarang Listrindo Tbk	Utilities	42.5%	↗57.5%	↗62.5%	↗67.5%
PT PLN Nusantara Power	Utilities	20.0%	↗45.0%	↗50.0%	↗53.0%

5. Reflecting Transition Risk in Probability of Default (PD) Stress Testing

Transition Risk Channels

The preceding sections highlight that Indonesia's transition risk is unlikely to be shaped by abrupt domestic policy tightening. Instead, the risk exposures are likely to reflect the interaction between global decarbonisation forces and the country's fossil-dependent energy and industrial systems. At the firm level, companies in the coal, oil, gas, electricity, and the rapidly expanding nickel-processing industries show limited operational decarbonisation and remain deeply tied to high-emission production models.

This dynamic creates sector-specific fault lines: borrowers in coal, oil, gas, electricity, and energy-intensive metal mining sectors face materially higher exposures to shifts in technology costs, carbon pricing policies and regulations, export-market requirements, and investor risk appetites.

We next developed the credit risk assessment and stress testing modules, by focusing on examining the additional default risks generated by climate change in these sectors. How should banks link transition-driven deterioration into probability of default (PDs) in a way that reflects market-driven risk transmission channels?

Transition-risk modelling ideally relies on structured, forward-looking scenarios. However, the Indonesian context (i.e., relatively stagnant sustainability policies) presents constraints on the level of granularity achievable in the modelling assumptions. Moreover, conducting firm-level or sectoral assessment to develop vulnerability function would require comprehensive data to support robust assumptions.

Given these constraints, the IMF has taken an early step to develop a stylised transition-risk analysis for Indonesia that incorporates sectoral pathways and indicative transition variables. The IMF explicitly frames this work as an exploratory

analysis relying on simplifying assumptions (See Figure 16 for IMF methodology).[21]

Figure 16 IMF Transition Risk Assessment Methodology

01	02	03	04	05
Nationwide	**Macro Modelling**	**Firm-Level**	**Sector-Level**	**Banking System**
Scenario Assumption	Macro Shock Factors	Firm vulnerability Indicators	Corporate Credit-Risk (PD) Path	Banking Credit Exposure
3 scenarios: Subsidy Redirection Scenario NDC Scenario NDC+ Scenario	Macro trajectory Sectoral production Energy price effect Investment pattern	Interest Coverage Ratio Leverage Ratio Current Ratio	PD Shift Sector-level risk path	Sectoral vulnerability by lending concentration

Adapted from: IMF Technical Note on Climate Risk Assessment

These limitations do not diminish the importance of assessing transition risk exposures. Rather, they demonstrate the limits of precise quantification at this stage. Given the implausibility of replicating the structural features (i.e. policy pathways, or sectoral fundamental assumption) of transition shocks in this context, we instead propose a conservative interim proxy based on the historical volatility of estimated PDs. This approach offers a canonical framework for assessing credit risk using readily available data. We acknowledge that the resulting estimates should be interpreted as indicative rather than scenario-equivalent.

Statistical Approach: Using Historical PD Volatility

This study adopts a statistical approach to approximate how transition pressures may translate into credit-risk amplification across sectors. Rather than attempting to construct long-horizon future cash-flow projections, which would require assumptions that cannot be robustly specified or simulated in Indonesia's current context, our proposed framework relies on empirically observable historical patterns in corporate default behaviour.

While direct empirical evidence linking climate transition policy to PD volatility remains limited, structural credit risk models suggest that transition-related price and policy uncertainty can widen firm value distributions and amplify default risk variability, thereby providing a conceptual foundation for this proxy.[22]

The core intuition underpinning our proposed approach is that sectors with structurally higher exposure to fossil-based input costs, global commodity cycles, and operational rigidity tend to exhibit greater PD volatility when faced with market or cost shocks. Even if Indonesia does not plan to undergo a full-scale transition, these historically observed variation offers a robust basis for quantifying which sectors are more susceptible to credit deterioration when exposed to transition-related stresses.

To operationalise this, we calculate the standard deviation (σ) of each sector's historical PD

distribution, and then apply a two-standard-deviation (2σ) increase to each sector's current PD. This produces a *"severe but plausible"* credit-risk shock that is grounded in prudential stress-testing practices. Importantly, this method is not aimed to reflect the structural dynamics of long-term decarbonisation pathways. Instead, it functions as a diagnostic tool that highlights where the banking system's credit exposures are most vulnerable based on historical patterns.

Caveats: Interpretation Limitations of the Statistical PD Approach

While the statistical PD-volatility method offers a practical framework to approximate transition-related credit sensitivity, several caveats must be acknowledged to ensure proper interpretation of the results.

First, the 2σ-PD shock could provide a forward-looking estimate of credit stress under historical conditions, but it does not replicate the multi-scenario frameworks used in various NGFS-aligned climate-risk assessments. In particular, it could understate future transition risks, in which structural policy, technology, or market shifts may generate credit stresses not yet observable in historical data (akin to the peso problem).

Second, Indonesia has not yet experienced transition-driven disruptions of the type seen in jurisdictions with rapid policy tightening. As a result, historical PD volatility largely reflects commodity cycles, operational shocks, and short-lived uncertainty episodes, for example during Covid-19, the coal and oil price swings, and election period volatility, rather than genuine transition-policy shocks.

Consequently, while our proposed method captures one important transition channel – i.e., market-driven stress transmitted through global demand and commodity prices, it does not fully capture the potential magnitude of longer-term structural pressures associated with sustained decarbonisation. For this reason, the estimated credit sensitivity could be interpreted as a conservative, lower-bound estimate of potential transition risk.

6. Methodology

This study adopts a statistical approach to assess how transition dynamics may translate into credit-risk amplification across sectors. Uneven and evolving climate transition policies generate uncertainty around future regulation, subsidies, and carbon pricing, which has been shown to increase volatility and risk spillovers in energy and financial markets.[23] Rather than attempting to construct long-horizon cash-flow projections, which would require assumptions that cannot be robustly specified in data-constrained contexts, our approach relies on observed historical variation in credit risk. This volatility disproportionately affects firms in sectors with high exposure to fossil fuels through repeated repricing of costs and revenues, leading to greater instability in asset values, credit quality, and default risk dynamics.[24]

We therefore proxy climate transition risk using the observed historical volatility of firm-level probabilities of default (PD) in sectors with high exposure to fossil fuels, i.e., with substantial revenue or asset exposure to coal, oil, gas, and fossil-fuel-based electricity generation. While direct empirical evidence linking climate transition policy to PD volatility remains limited, structural credit risk models show that transition-related price and policy uncertainty widens firm value distributions and amplifies default risk variability, providing a conceptual foundation for this proxy.[25]

To operationalize this approach, we first compute the standard deviation (σ) of each sector's historical PD distribution over the preceding decade. We then apply an increase equal to twice this amount (2σ) to sector-level PDs. This

calibration generates a severe but plausible credit-risk shock that is consistent with standard prudential stress-testing conventions. The exercise is not intended to capture the structural dynamics of long-term decarbonisation pathways at the country or sector level, nor to forecast equilibrium outcomes under specific policy scenarios. Instead, it facilitates the identification of sectors where credit risk has been most sensitive to cost and market volatility and then applies calibrated shocks to examine how transition-related shocks could propagate vulnerabilities at the level of individual banks and across the banking system.

Sector-Level Probabilities of Default (PDs)

We first construct daily sector-level aggregated PD series for each sector s over the period 2015–2025. Using these time series, we estimate σ_s as the standard deviation of the daily observations. We then simulate a $2\sigma_s$ shock as an additive upward shift applied to the sector's annual PD, $PD_{s,t}$, which is defined as the average of daily PD values over year t. Under the simulated $2\sigma_s$ PD shock, the sector-level default probabilities therefore increase to:

$$PD_{s,t}^{(2\sigma)} = PD_{s,t} + 2\sigma_s$$

Expected Losses

Expected losses (EL) for a given sector portfolio in year t are computed using the standard credit-risk formula:

$$EL_{s,t} = PD_{s,t} \times LGD_{s,t} \times EAD_{s,t}$$

We can aggregate sectors into a sector set G, and calculate the expected losses for the set G as:

$$EL_{G,t} = \sum_{s \in G} PD_{s,t} \times LGD_{s,t} \times EAD_{s,t}$$

Under the simulated $2\sigma_s$ PD shock, the expected losses for the set G increases to:

$$EL_{G,t}^{(2\sigma)} = \sum_{s \in G} PD_{s,t}^{(2\sigma)} \times LGD_{s,t} \times EAD_{s,t}$$

The stressed probabilities of default $PD_{s,t}^{(2\sigma)}$ reflect the sector-specific $2\sigma\_s$shocks calibrated from the historical volatility of sector-level PDs. The resulting increase in expected losses is calculated annually for each sector, based on the loan exposure to that sector, allowing potential losses arising from PD shocks to be decomposed into sector-level contributions.

The framework enables aggregation at the bank level (with G encompassing all sectors) and sectoral levels (with G encompassing an individual sector or selected sector grouping, either within each bank or across banks). In this study, the set G is primarily defined along a sectoral carbon-intensity dimension, distinguishing between fossil-intensive and low-carbon sectors based on their exposure to fossil fuel activities and associated transition risks. This classification enables expected losses to be decomposed by sector type and facilitates a comparison of baseline and stressed credit risk contributions from carbon-intensive versus low-carbon loan exposures, both in aggregate and within individual banks' portfolios.

We apply this framework by computing sector-level expected losses under a $2\sigma_s$ shock applied to baseline sectoral PDs for each bank's portfolio over the 2015–2025 horizon and aggregating these sectoral losses into fossil-intensive and low-carbon sectoral groupings. We then compare fossil-intensive and low-carbon loss components across banks to assess heterogeneity in exposures to carbon-related transition risk. We use visualizations to illustrate patterns of vulnerability and loss concentration below.

While expected losses are informative in absolute terms, cross-bank comparisons are inevitably confounded by differences in loan portfolio sizes. In particular, banks with larger loan books

mechanically exhibit higher expected loss amounts even when underlying credit risk is similar. To net out this exposure-scale effect and enable more comparable assessment across banks and over time, we therefore focus on expected loss intensity, defined as expected losses normalized by the corresponding loan exposure. For a given portfolio group G in year t, we define:

$$Loss\ Intensity_{G,t} = \frac{EL_{G,t}}{\sum_{s \in G} EAD_{s,t}},$$

The stressed expected loss intensity is computed as:

$$Loss\ Intensity_{G,t}^{(2\sigma)} = \frac{EL_{G,t}^{(2\sigma)}}{\sum_{s \in G} EAD_{s,t}}.$$

To isolate the effect of stressing fossil-intensive activities only, we construct a "carbon-intensive-shock-only" measure. We denote the set of fossil-intensive sectors as C. We then stress the default probabilities only for sectors $s \in C$, while default probability for all other sectors remain at their baseline levels. Expected losses and loss intensity under this carbon-Intensive-shock-only scenario can be computed as:

$$
\begin{aligned}
EL_{G,t}^{(2\sigma,C)} &= \sum_{s \in C} (PD_{s,t}^{(2\sigma)} \times LGD_{s,t} \times EAD_{s,t}) \\
&\quad + \sum_{s \notin C} (PD_{s,t} \times LGD_{s,t} \times EAD_{s,t}), \\
&= EL_{G,t} + \sum_{s \in C} (2\sigma_s \times LGD_{s,t} \times EAD_{s,t}),
\end{aligned}
$$

and

$$Loss\ Intensity_{g,t}^{(2\sigma,C)} = \frac{EL_{G,t}^{(2\sigma,C)}}{\sum_{s \in G} EAD_{s,t}}.$$

This scenario is particularly important because it isolates the contribution of carbon-intensive exposures to overall credit risk, while holding risk conditions in low-carbon sectors constant. By comparing outcomes under the carbon-intensive-shock-only scenario to those obtained under the economy-wide stress, we can assess the extent to which each bank's credit risk exposure is due to fossil-intensive activities rather than generalized credit deterioration. This distinction is crucial for evaluating the role of portfolio composition in shaping exposure to transition risk and for identifying banks whose risk profiles are disproportionately sensitive to transition shocks originating in fossil-intensive sectors.

Assumptions

In developing the methodology for the stress-testing framework, we adopt several simplifying assumptions to isolate transition risk effects. Loss Given Default (LGD) and Exposure at Default (EAD) are held constant across scenarios to ensure comparability by isolating the impact of PD shocks. LGD is assumed to be 100 percent, implying a zero Recovery Rate. AIDF-CRI does not estimate PDs for non-publicly listed firms. For such firms appearing in the bank loan portfolios, PDs are imputed using the corresponding annual sector-level aggregated PD, defined as the annual mean of daily median PD values of publicly listed firms within the same sector. Stress is introduced through a simulated two-standard-deviation (2σ) PD shock applied at the sector level, representing an extreme but still plausible event, aligned with regulatory stress-test practices. Within each sector, PD shocks are assumed to be homogeneous to maintain internal consistency while preserving cross-sector heterogeneity. Finally, a static balance-sheet assumption is adopted, under which banks do not rebalance or hedge their exposures over the stress horizon.

7. Results

Figure 17 PD with 2σ Increase for Various Sectors
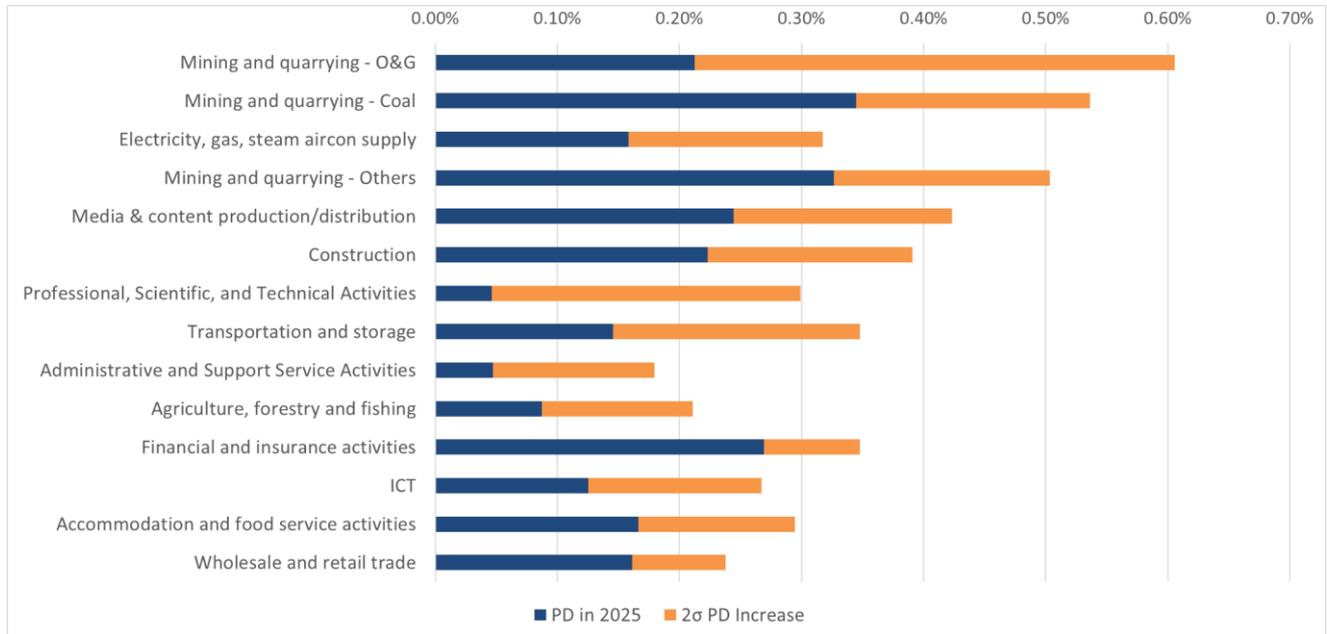
Applying 2σ PD Shock to Fossil-intensive sectors

Figure 17 visualizes the effect of applying the 2σ PD shock across sectors. The first three sectors correspond to the fossil-intensive sectors and exhibit larger increases in credit-loss outcomes with the PD shocks.

Quantitatively, the implied 2σ PD stress add-ons for the three fossil-intensive sectors are sizeable.

- Mining and quarrying - O&G, the orange segment corresponds to an increase of roughly **39 basis points (bps)**;
- Mining and quarrying – Coal, the 2σ uplift is also about **19 bps**;
- Electricity, gas, steam and air-conditioning supply, the 2σ increase is at around **16 bps**.

These magnitudes illustrate that the stress scenario embeds a materially stronger deterioration for the fossil-intensive sectors than for most other industries, consistent with their greater sensitivity to transition-related shocks.

To facilitate the interpretation of the 2σ shock at the sector level, we use the case of coal miners' aggregate 1-year PD from 2015 to 2025 as illustration. The yellow line in Figure 18 plots the NUS-CRI aggregate PD for Indonesian coal miners, while the red dashed line marks the upper bound of the BBB rating range and the black line represents the yearly median PD level (Baseline PD) in 2025. The orange horizontal line shows the 2σ shocked PD, defined as the baseline PD plus two standard deviations of historical PD fluctuations.

Figure 18 Stress Testing Result Example: Coal Miners' Baseline and 2Sigma Shock
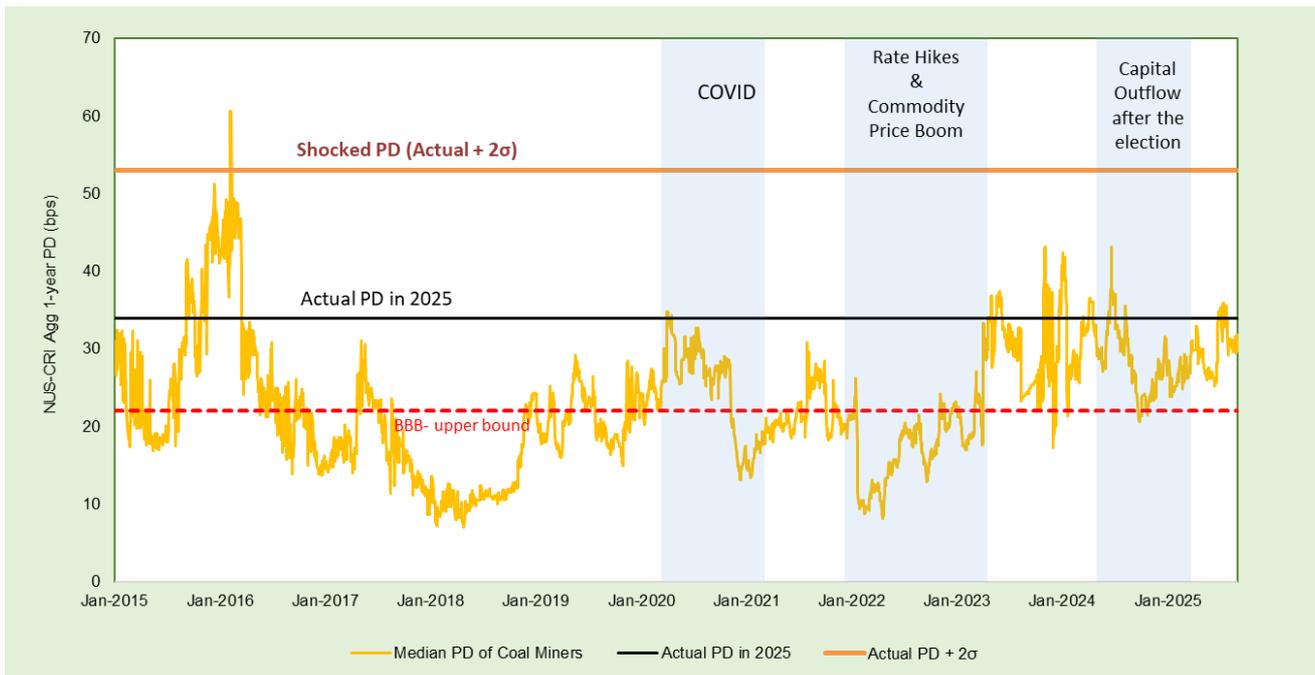
Figure 18 highlights several key features. First, coal miners' PD is volatile and event-driven: it spiked during the 2015–2016 global commodity and coal price downturn, rose around COVID, and dropped through the period of commodity price boom. Second, the coal miners' PD generally lies above the BBB- upper bound after 2023, indicating the sector's declining credit quality. Third, with the 2σ increase, the stressed PD level for coal miners is well above both the BBB threshold and the recent PDs—illustrating how a severe but plausible transition-related shock can generate large tail losses in this sector.

Coal Miners' PD and International Coal Prices

An analysis of the coal miners' Aggregate PD under the baseline and 2σ shock, combined with key event markers, shows that credit risk in the coal sector is closely linked to **global coal-price dynamics.** Figure 19 uses two international coal price indices. The contemporaneous correlation between each of the two price indices and sectoral PD is **around –0.3: lower coal prices tend to be associated with higher default risk for coal miners.**

Moreover, the negative correlation remains sizable and statistically meaningful for several lags: **the sensitivity of sector PDs to coal-price movements is strongest contemporaneously but it tends to persist for up to half a year.** This indicates that coal-price shocks do not fully wash out immediately but instead affect the credit risk of coal miners over multiple quarters, reinforcing the combined impact of market cycles and potential structural decarbonisation pressures.

Figure 19 Coal Price and Coal Miners PD
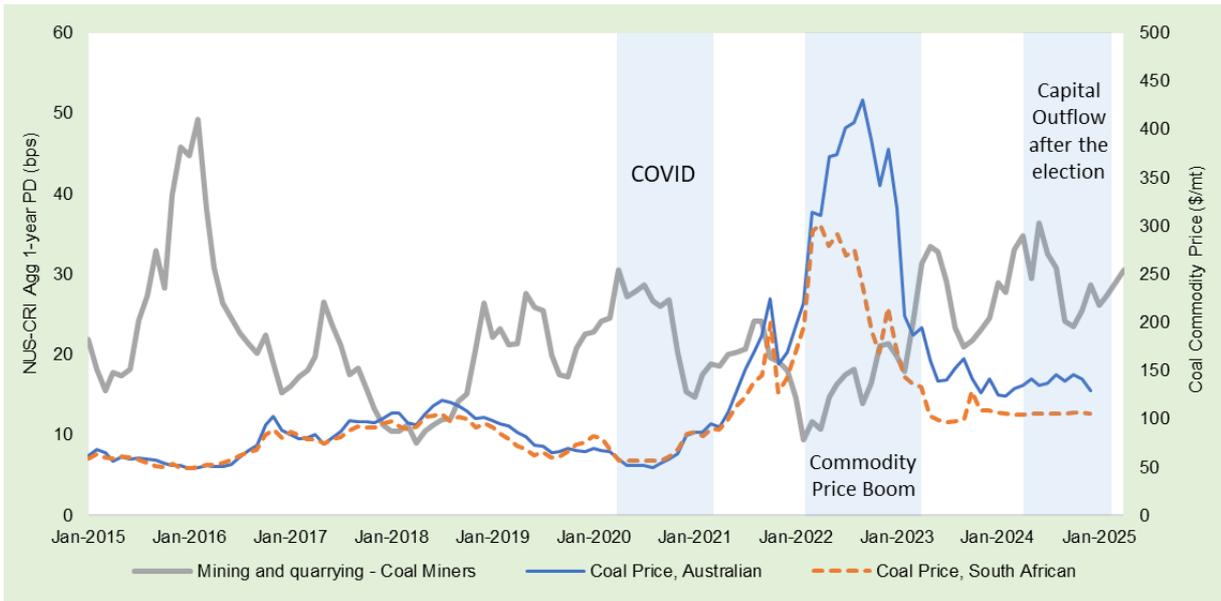
Bank Portfolio's Expected Loss (EL)

We show the annual additional EL from 2σ PD shock from both the fossil-intensive and non-fossil-intensive sectors in Figure 20.

Under the 2σ PD shock, after-shock EL is **higher by roughly 64-120 percent** than the baseline EL across 2015–2025.

Comparing the additional expected loss from the fossil-intensive sectors and non-fossil-intensive sectors, we observe in Figure 21 that the **fossil-intensive sectors account for around half of the incremental EL across the past 5 years.**

Figure 20 Total Expected Loss under 2 Sigma PD Shock
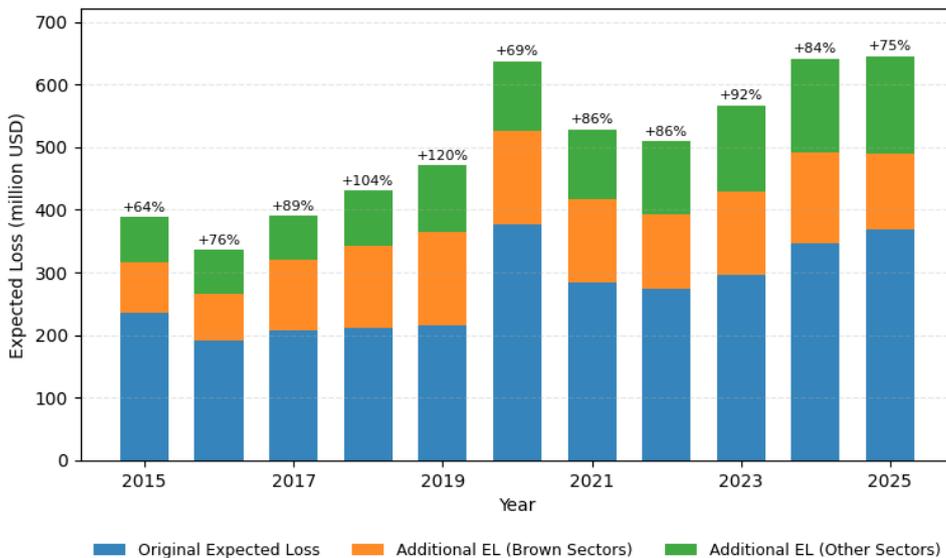
Figure 21 Additional Expected Loss Composition
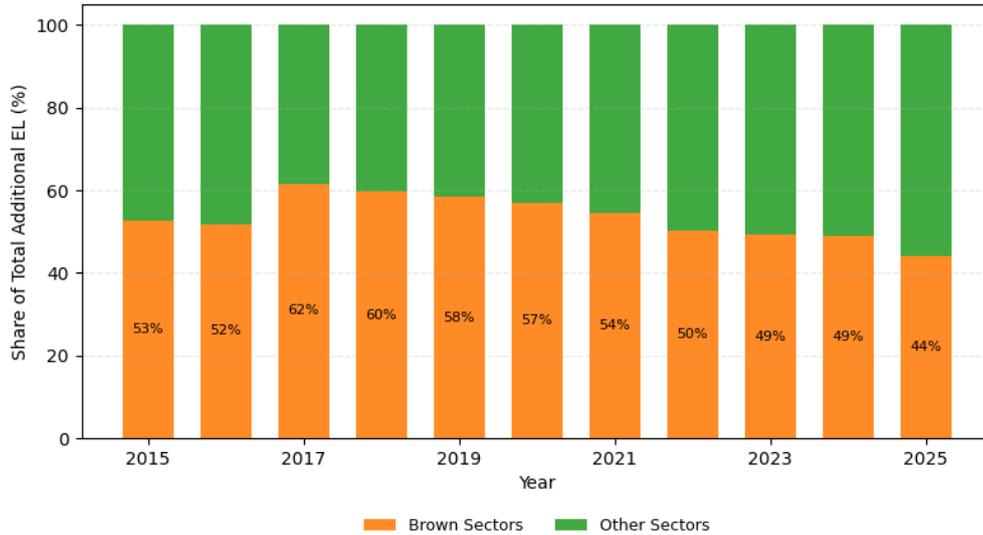
Bank-Group Stress Test Outcomes

From this section onward, the stress test will focus on fossil-intensive sectors, as these sectors are most exposed to transition risk, which makes them the most informative part of the portfolio for assessing downside credit-loss outcomes under adverse shocks. Figure 22 reports the 2σ PD shock results for each bank (or bank group), decomposing annual EL into two components: baseline EL using observed PD (blue) and the additional expected loss associated with a 2σ increase in the PD from fossil-intensive sectors (orange).

Figure 22 Increasing Fossil-Intensive Sectoral PD by 2σ
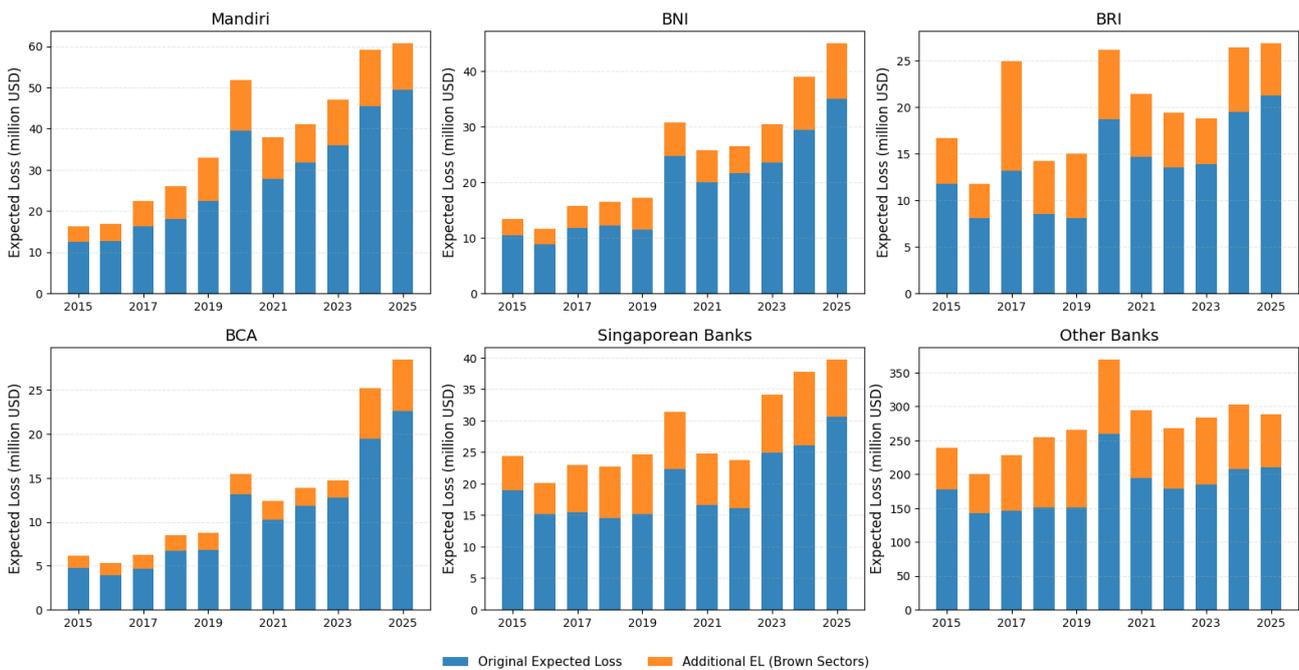
For the major Indonesian banks—including large state-owned institutions (Mandiri, BNI and BRI) and the largest private bank (BCA)—baseline EL generally trends upward over 2015–2025, with a pronounced step-up around 2020 and losses remaining elevated thereafter. The stacked bars show that the 2σ PD shock in fossil-intensive sectors adds a material layer of incremental expected losses in most years, indicating that transition-risk shocks can meaningfully raise expected losses above the baseline even when focusing solely on carbon-intensive exposures. Relative to the state-owned banks, BCA starts from a lower expected-loss level but exhibits a clear upward trajectory, with the fossil-intensive sectors shock contributing a non-trivial incremental increase especially in the later years. Among individual banks, Mandiri experienced the largest absolute stressed losses, consistent with its larger loan book and/or higher underlying risk.

Singaporean banks (including DBS, UOB and OCBC) display moderate baseline losses, but the additional expected loss under the 2σ fossil-intensive sectors PD shock (orange) also rises over time (especially from the early 2020s) indicating an increasing contribution of fossil-intensive sectors exposures to expected losses as regional project finance and cross-border lending expanded.

"Other Banks" comprise a large number of smaller domestic institutions as well as foreign institutions. For this group, the fossil-intensive sectors shock contributes a sizeable incremental layer of expected losses post 2020.

While the stacked bars are informative about the evolution of expected losses in absolute terms, cross-group comparisons are inevitably confounded by differences in portfolio size. In particular, larger loan books mechanically generate larger expected loss amounts even when underlying credit risk is similar. To net out this exposure-scale effect and enable more

comparable assessment across banks and over time, we therefore turn to expected loss intensity, defined as expected losses normalised by the corresponding loan exposure.

Expected Loss Intensity under 2σ PD Shock

Expected loss intensity, defined as expected loss normalized by total loan exposure, is useful to provide sector-adjusted measure of vulnerability.

Expected loss intensity is computed consistently with the group definition g. For a given portfolio group g in year t in sector s, we define:

$$\text{Loss Intensity}_{g,t} = \frac{EL_{g,t}}{EAD_{g,t}}$$

$$EAD_{g,t} = \sum_{s \in S} EAD_{g,s,t},$$

with stressed expected losses given by:

$$EL_{g,t}^{(2\sigma)} = \sum_{s \in S} (PD_{s,t}^{(2\sigma)} \times LGD_{s,t} \times EAD_{g,s,t})$$

expected loss intensity are computed as:

$$\text{Loss Intensity}_{g,t}^{(2\sigma)} = \frac{EL_{g,t}^{(2\sigma)}}{EAD_{g,t}}.$$

To isolate the effect of stressing only carbon-intensive activities, we also consider a "carbon-intensive-shock-only" variant. Let $B \subseteq S$ denote the set of fossil-intensive sectors. We stress default probabilities only for sectors $s \in B$, leaving all other sectors unchanged:

$$PD_{s,t}^{(2\sigma,B)} = PD_{s,t} + 2\sigma_s\, 1\{s \in B\}.$$

Stressed expected losses and loss intensity under the carbon intensive-shock-only scenario are then computed as:

$$EL_{g,t}^{(2\sigma,B)} = \sum_{s \in S} (PD_{s,t}^{(2\sigma,B)} \times LGD_{s,t} \times EAD_{g,s,t}),$$

$$\text{Loss Intensity}_{g,t}^{(2\sigma,B)} = \frac{EL_{g,t}^{(2\sigma,B)}}{EAD_{g,t}}.$$

We depict the loss intensity of fossil-intensive sectors in Figure 25. The figure shows the after-shock loss intensity of fossil-intensive sectors exposures across Mandiri, BNI, BRI, BCA, Singaporean Banks, and Other Banks over 2019–2025. Loss intensity rises sharply in 2020,

moderates in 2021–2022, and then increases again from 2023, peaking around 2024 before remaining elevated in 2025. Overall, the pattern indicates that a given unit of loan exposure to fossil-related activities can generate sizeable stressed expected losses, with the post-2023 period marked by a broad-based upward shift across bank groups.

Figure 23 Fossil-intensive Sector Loss Intensity under 2Sigma PD Shock for different Bank Groups
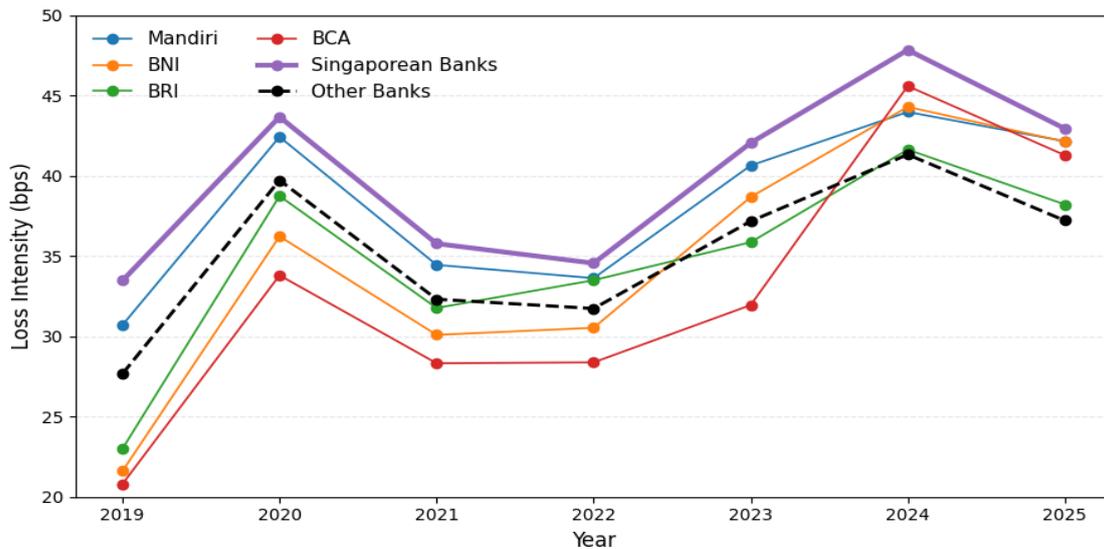
For Mandiri, BNI, and BRI, fossil-intensive sectors loss intensity spikes in 2020, then sits at a lower level in 2021–2022 before rising again toward 2024. BCA follows a similar pattern but with a more pronounced acceleration from 2023 to 2024. Cross-sectionally, Singaporean banks stand out as having the highest fossil-intensive sectors loss intensity in most years. In 2025, their loss intensity is around **43 bps**, typically ~1–2 bps above Mandiri and BNI and roughly ~5–6 bps higher than BRI and Other Banks, indicating relatively higher stressed expected losses per unit of fossil-intensive sectors exposure for cross-border lenders.

To provide an **exposure-normalised** point estimate for the full reconstructed loan book, we additionally report aggregate (all-bank) loss intensity for the combined portfolio in Figure 26.

This overall series serves two purposes. First, it confirms that the aggregate time profile is not driven solely by any single bank group. Second, it yields a policy-relevant headline statistic that can be directly benchmarked against other intensity-based measures (e.g., the physical-risk exposure/intensity metrics reported in Section IV).

In this figure, the post-shock series (orange) consistently lies above the baseline (blue), and the two lines move broadly in parallel—both peak in 2020, ease in 2021–2023 and then edge up again in 2024–2025. The gap between the two series is fairly stable, typically staying in the range of about 6–9 bps, with most years clustering around ~7–8 bps.

Figure 26 Overall Loss Intensity Under Baseline and 2σ Shock Applied to Fossil-intensive sectors
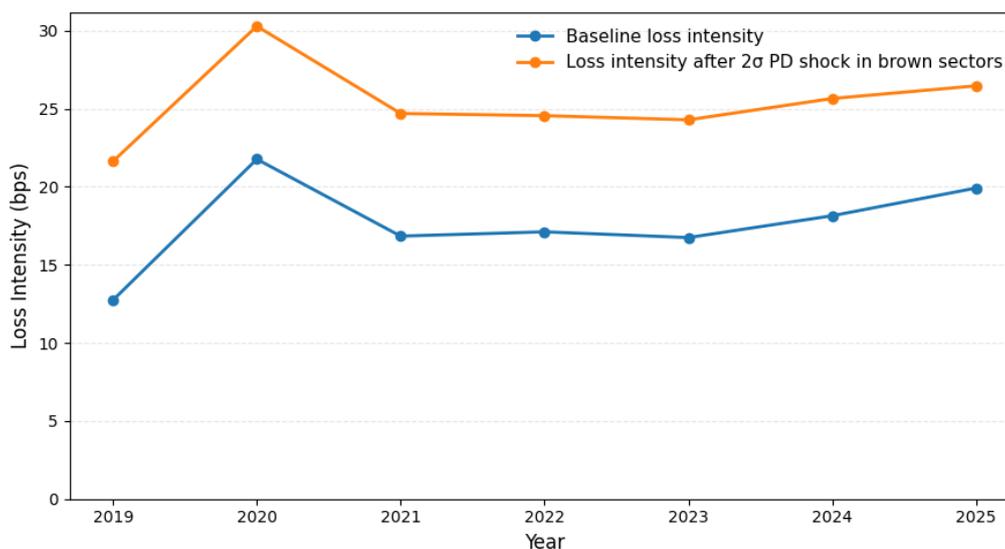
Overall, Figure 23 and Figure 26 show that:

(i) loss intensity in fossil-intensive sectors increases steadily since 2019, with a clear step-up in the post-2020 period and remaining elevated in recent years.

(ii) Singaporean banks exhibit the highest (or among the highest) fossil-intensive sectors loss intensity across the sample period, consistently above their non-fossil-intensive benchmark.

(iii) **Overall, the 2025 baseline expected loss intensity is ~20 bps, rising to ~27 bps under the 2σ PD shock applied to fossil-intensive sectors exposures.**

The framework enables aggregation at the bank, and sector levels. We visualize the results below to identify patterns in vulnerability and loss concentration.

8. Analysis

Taken together, the stress-test results – based on observed PD dynamics over the past decade – show that transition-related shocks can meaningfully reshape banks' credit risk profiles. The historical volatility in PDs reflects how corporate credit quality has responded to different market, commodity-price, and policy events. Historical data cannot predict future outcomes of decarbonisation, but it nonetheless offers useful insights on how banks' credit risk, and hence expected losses, may evolve as transition policies tighten around the world and portfolio exposures shift in the future. Developing the 2σ PD shock framework using this historical backdrop allows us to interpret it as a stylised but still plausible "stress point" near the upper end of realised PD swings, illustrating how losses could escalate if transition dynamics move into more adverse territory for Indonesia's fossil-fuel-dependent economy. Our results also show that carbon-intensive activities account for a disproportionate share of stressed losses.

In this setting, concentrated exposures to high-emission, transition-sensitive fossil-intensive sectors (especially coal, oil and gas, and electricity) can act as amplifiers of portfolio losses, particularly for institutions with limited sectoral diversification. Overall, **the findings underscore the need to embed climate-transition parameters into prudential stress**

testing frameworks, align lending strategies and sector limits with credible decarbonisation pathways, and strengthen risk-governance and capital-planning frameworks in the banking sector so that climate transition risk is managed proactively rather than reactively.

Chapter IV

Physical Risk

IV. Physical Risk

Assessing the resilience of financial-sector to climate risk requires examining the physical-risk landscape of various geographies in Indonesia and understanding how climate-related hazards affect banks' loan portfolios. Physical risks can erode asset values, reducing the quality of collateral held by banks. They can also disrupt borrowers' operations, weakening their ability to service debt. Together, these effects increase banks' potential credit losses. In Indonesia, these risks are closely intertwined with transition risk as a substantial share of energy, manufacturing, and mining assets is concentrated in hazard-prone areas.[26]

Indonesia's exposure spans multiple climate hazards, including floods, drought, wildfires, sea-level rise, and extreme heat. National Disaster Management Agency (BNPB) data show a persistent increase in disaster events since 2008, signalling rising climate hazard volatility (See Figure 24). In 2021, World Bank places Indonesia within the top third of countries worldwide for overall climate risk, driven by consistently high exposure to flooding and extreme heat.[27]

1. Focusing on flood risks

Among multiple climatic drivers, floods stand out as one of the most frequently cited physical hazards in the latest United Nations Framework Convention on Climate Change (UNFCCC) NDC Synthesis Report, which notes that over one-quarter of Parties identify floods as a top physical-impact driver for infrastructure, energy, transport, and urban systems[28]. The OECD ranked Indonesia 17th globally in terms of projected exposure to riverine and coastal flooding[29].

Recent catastrophic floods and landslides in Sumatra in December 2025 resulted in over 1,000 confirmed deaths, displaced hundreds of thousands of people, and overwhelmed relief efforts. This underscores the severity of flood risk on the ground. The disaster paralyzed broad swaths of northern Sumatra, causing widespread shortages and infrastructure damage. This scale of impact illustrates how physical hazards can translate into profound socio-economic disruptions in exposed regions.

Economic concentration further amplifies this risk with more than 50 percent of Indonesia's GDP comings from DKI Jakarta, East Java, West Java, and Central Java. Moreover, 32.38 percent of total commercial credit was recorded in DKI Jakarta as of September 2025[30] while on the other side, recurring inundations already cause annual losses exceeding USD 125 million (IDR 2.1 trillion) in Jakarta alone.[31]

Figure 24 Disaster Events in Indonesia
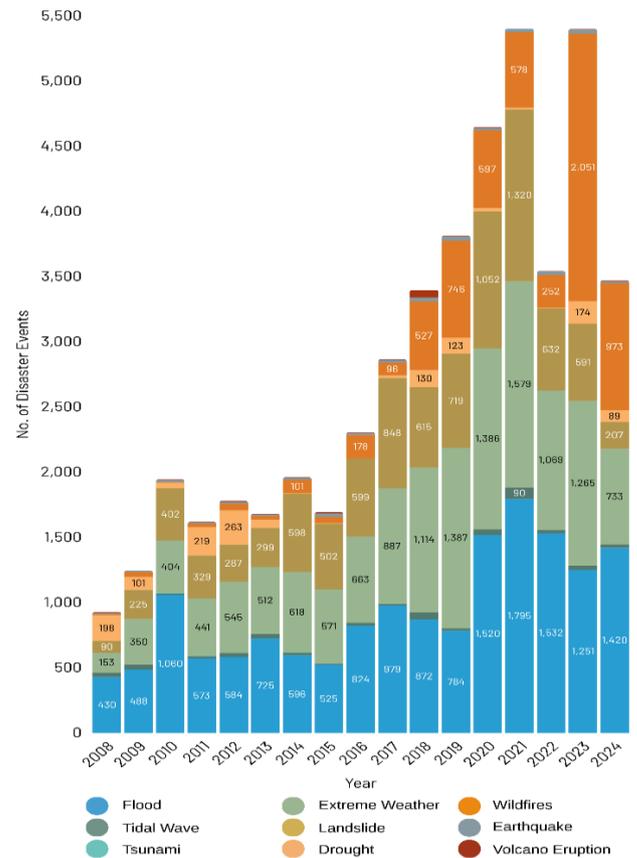
Source: BNPB

Moreover, sectoral patterns suggest that many fossil-intensive sectors are also highly exposed to flood risk due to their geographic concentration in flood-prone areas, underscoring the structural alignment between physical and transition risks in Indonesia. A 2021 report from Mining Advocacy Network (JATAM) mentioned that 2,104 mining concession are in high-risk flood areas.[32]

This combination of hazard prevalence, asset concentration, and sectoral sensitivity increases the likelihood that floods transmit into financial-system vulnerabilities through direct asset damage, collateral impairment, business disruption, and spillover through regional concentration of borrowers.[33] These dynamics justify prioritising flood risk in the physical-risk assessment and motivate the development of spatially explicit exposure estimates.

Flood Risk Patterns

Flood risk is not monolithic. Each hazard has different spatial patterns, recurrence patterns, damage mechanisms, and implications for bank's exposure. For financial institutions, distinguishing between flood types is important, as Indonesia faces material exposure to three dominant flood types.

Coastal Flood

Coastal flooding is driven by sea-level rise, land subsidence, storm surge, and tidal anomalies.[34] Given Indonesia's geographic characteristics as an archipelagic country, many areas are exposed to this type of flood. This would affect critical assets such as ports, logistic hub, industrial estates, and export-oriented zones.

In Java, one of the most densely populated and economically important regions, coastal flood risk is rising sharply. With climate risk increasing, potential of tidal flood occurrence also rises.[35] For banks, coastal flood risk threatens critical supply-chain assets, port-linked industries, and mortgage portfolios in subsiding coastal towns.

Fluvial (Riverine) Flood

Riverine flooding occurs when rivers overflow following prolonged or high-intensity rainfall, influenced by upstream land-use change and watershed degradation. These events typically unfold at a regional scale, following the hydrological boundaries of river basins rather than administrative borders. World Bank database shows that Indonesia has a high risk of river flooding with medium confidence that climate change is expected to increase this risk due to more frequent and more intense heavy rainfall days and extreme precipitation events.[36] As these trends continue, today's flood hazard levels are likely to rise in the future. Riverine floods pose a direct threat to economic centres like manufacturing centres, agro-processing facilities, and resource-extraction sites that are situated along river basins, increasing the likelihood of collateral impairment, inventory loss, and business interruption for borrowers located along these river systems.

Pluvial (Urban) Flood

World Bank modelling result shows Indonesia as a high-risk country of urban flood.[37] Urban flooding or pluvial flood, is one type of flood caused by high rainfall that exceeds the capacity of drainage systems, causing water to accumulate in dense urban areas. This type of flood is usually repetitive, resulting in systemic impact for the local communities.[38]

BNPB data shows that major cities in Indonesia like Jakarta[39], Bandung[40], Makassar[41], Surabaya[42], Palembang[43], Samarinda[44], and Denpasar[45] face this challenge. With this hazard directly affecting commercial districts, industrial parks, and household, pluvial floods create frequent, short-cycle, business disruptions.

2. Climate Scenario Analysis

Climate flood scenarios

Climate flood scenarios provide the forward-looking hazard trajectories needed to assess how flood risks may evolve over time. Modern climate-risk analysis relies primarily on the Shared Socioeconomic Pathways (SSPs) and the Network for Greening the Financial System (NGFS) scenarios, with the Representative Concentration Pathways (RCPs) serving as legacy forcing trajectories used in earlier modelling studies.

The RCPs illustrate alternative greenhouse gas concentration trajectories and associated radiative forcing levels. Developed for the Coupled Model Intercomparison Project (CMIP) 5 modelling framework, they formed the basis of the physical climate projections assessed in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5).[46] Although RCP-based projections are still used in some legacy climate and hydrological modelling tools, they have been largely superseded by the SSP-based framework adopted in CMIP6.

More recent climate assessments draw on the CMIP6 framework, which adopts the SSPs as the primary scenario architecture. The SSPs integrate socioeconomic, technological, and policy development pathways with associated emissions trajectories, enabling a more integrated assessment of future warming outcomes (See Table 3).[47]

Table 3 SSP Scenarios Major Assumptions

Scenario	Global Approx. Warming by 2100	RCP equivalent	Socioeconomic Context	Emission Scenario
SSP1-1.9	Warming Limit to 1.5°C	-	**Sustainability**-driven pathway with rapid decarbonisation and low inequality	Very low
SSP1-2.6	Warming Limit to 2°C	RCP 2.6	**Sustainability** with slower mitigation	Low
SSP2-4.5	Warming Limit to 3°C	RCP 4.5	**Middle of the road** development, moderate fossil reliance and gradual transition	Intermediate
SSP3-7.0	Warming Limit to 4°C		**Regional rivalry**, weak institution, high population, slow technological development and high fossil use	High
SSP5-8.5	Warming exceed of 4°C	RCP 8.5	**Fossil-fueled development**, high consumption, high economic expansion	Very High

Note: Some climate modelling also use SSP4-3.4 or SSP4-6.0 scenarios to represent Inequality scenarios, but only scenarios mentioned above are used in the AR6 working group report.

Adapted from: IPCC & Climate Data Canada

Independent assessments, including those by Climate Action Tracker, indicate that current global policies broadly align with the intermediate warming range consistent with **SSP2-4.5**.[48] This pathway therefore provides a suitable **baseline scenario** for physical climate risk assessment. Higher-emissions pathways, such as SSP3-7.0 and SSP5-8.5, represent increasingly severe warming outcomes. **SSP3-7.0** is generally considered more **severe but plausible** under limited climate policy progress, and **SSP5-8.5** reflects a **low-likelihood but high-impact stress case**. For Indonesia, this implies an approximate warming of around 2°C by 2100 under SSP2-4.5, with more severe scenarios potentially resulting in temperature increases of around 4°C or higher. (See the right panel of Figure 25).

Figure 25 Time Series of Annual Daily Mean Temperature for Indonesia Under SSP Scenarios
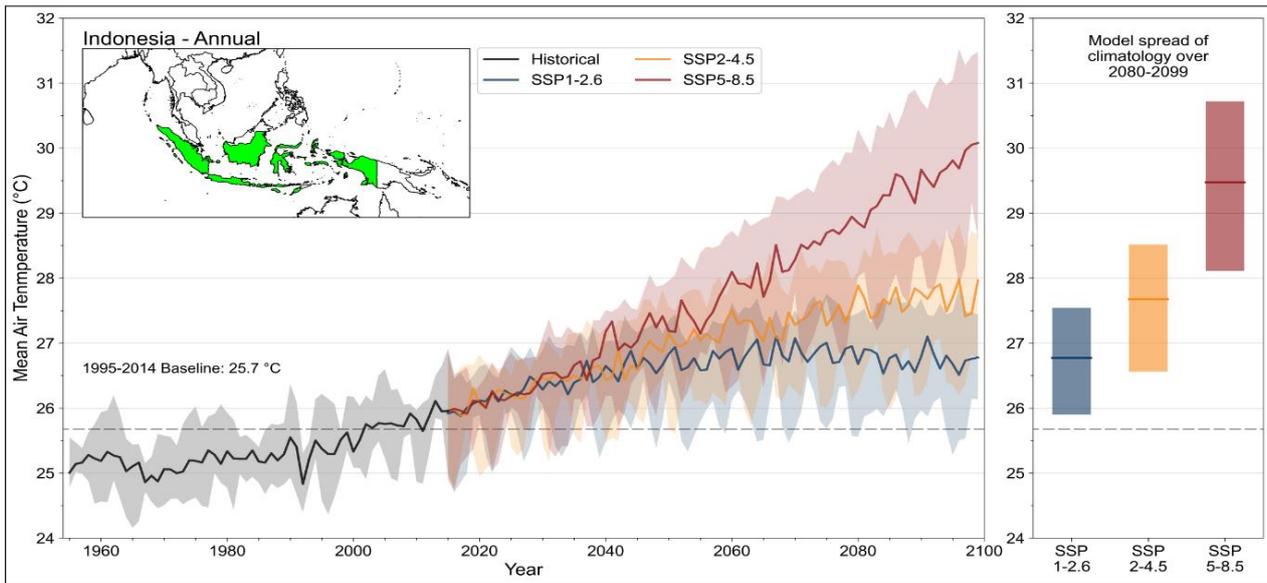
Note: The side panel shows the model spread of the 2080-2099 climatology in annual mean temperature averaged over Indonesia for each SSP. The full range of possible values averaged over 2080-2099 are shown as coloured bars, one for each scenario: SSP1-2.6 (blue), SSP2-4.5 (orange), and SSP5-8.5 (red), with the median value shown by the horizontal line.

Adapted from: National Environment Agency, Singapore.

Underlying Scenario for Physical Risk

As recent emissions trajectory lies within the SSP2-4.5 scenario, our analysis adopts the Intermediate **(SSP2-4.5) scenario as a baseline**, representing a stabilising but incomplete mitigation pathway, and examines incremental flood-risk impacts under the **High (SSP3-7.0)** and **Very High (SSP5-8.5)** scenarios to capture upper-bound hazard intensification consistent with global climate projections used internationally.

NGFS Scenarios for Supervisory Relevance

NGFS adapts IPCC climate pathways into a structured set of scenarios designed specifically for financial-sector stress testing (See Figure 26). NGFS socioeconomic projections and assumptions are aligned with SSP2 warming scenarios but extend them with assumptions on transition policies, energy system change, carbon pricing, and macro-financial conditions for financial-sector stress testing.

Figure 26 NGFS Scenarios Phase V

Adopted from NGFS

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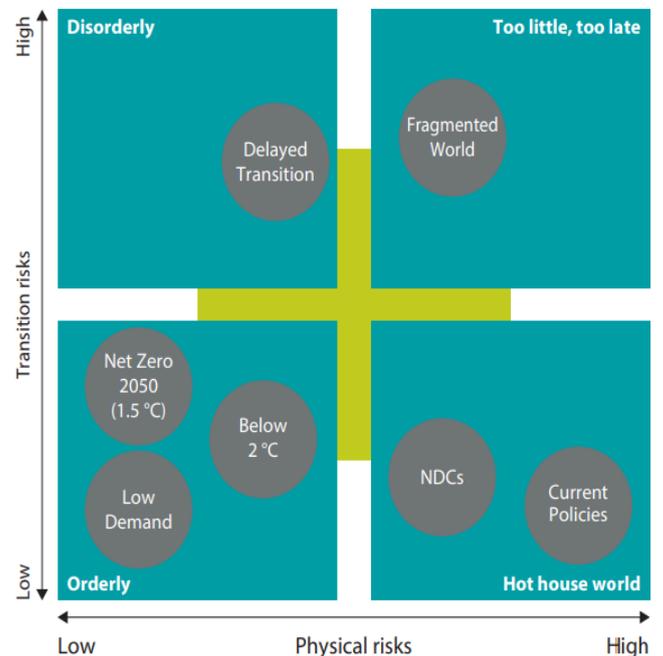
NGFS Phase V does not provide a formal correspondence to IPCC SSP pathways, and its scenarios are not calibrated to match the emissions, radiative forcing, or temperature outcomes of any specific SSP. Although NGFS adopts socioeconomic assumptions consistent with the "middle-of-the-road" SSP2 worldview, the resulting climate trajectories differ substantially from the SSP family. Importantly, the NGFS high-emission scenarios produce lower warming than the high-emission SSP3-7.0 and SSP5-8.5 pathways (See Table 4).

Although our assessment relies entirely on SSP-based climate projections for modelling flood hazard trajectories, NGFS scenarios are briefly introduced to situate the analysis within a supervisory context. Many financial-sector users interpret climate futures through the NGFS framework. Therefore, a short comparison here intended to help orient readers without implying methodological alignment.

While both NGFS and SSP storylines offer a familiar vocabulary for describing broad global challenges, the higher warming levels associated with SSP3-7.0 and SSP5-8.5 place these pathways outside the physical-severity range represented in any NGFS scenario. Because physical hazards scale with global climate forcing, SSP high-emission worlds capture upper-end flood intensification that NGFS does not cover. This distinction relates solely to the range of physical conditions and does not imply any narrative, structural, or methodological correspondence between the two frameworks.

Table 4 NGFS Scenarios Major Assumptions

Category	NGFS Scenario	Global 2100 Warming	Scenario Narratives
Orderly	Low Demand	1.1°C -1.6°C	Immediate policy action, fast technological change, medium policy variation
	Net Zero 2050	1.4°C -1.7°C	
	Below 2°C	1.8°C	Immediate policy action, moderate technological change, low policy variation
Disorderly	Delayed Transition	1.7°C-1.8°C	Delayed policy action, uneven technological change, high policy variation
Hot House World	NDCs	2.3°C	NDCs, slow technological change, medium policy variation
	Current Policies	3.0°C	Continuation of existing policies, slow changing technology, low policy variation
Too-little-too-late	Fragmented World	2.4°C	Delayed and fragmented policy, slow and fragmented technological change, high policy variation

Note: Based on alignment between NGFS scenario and RCP emissions trajectories, Current Policies scenario is mapped into RCP 4.5, in which aligned with SSP2-4.5 scenario.[49]

Adapted from: NGFS Technical Documentation Phase V

Time horizon

Long-term Trajectory to 2060

Indonesia's long-term climate and energy planning frameworks including RUKN, long-term strategy for low carbon and climate resilience (LTS-LCCR), and NDC, anchor national mitigation and energy pathways to a 2060 horizon. NGFS also uses 2060 as a long-term horizon, which translated into central banks and supervisory frameworks.[50]

In climate-risk analysis, this long-term horizon is not intended to reflect the maturity of bank loans but to provide a comprehensive view of how physical hazards intensify over time, recognising that climate impacts evolve gradually and many material changes emerge around mid-century.[51]

While most credit exposures mature well before 2060, understanding the evolution of hazards over this period helps contextualise medium-term risks that can influence counterparties' operating quality, and sectoral resilience. For these reasons, 2060 is used as a reference point for tracing the long-term progression of physical risk, while the credit-risk interpretation remains focused on nearer-term dynamics relevant to banks.

Extension to 2090

Although 2060 serves as the primary policy and financial-planning horizon, extending the analysis to 2090 provides a clearer view of the long-run trajectory of physical hazards. Multiple CMIP6-based studies indicate that extreme precipitation, flood magnitudes, inundation extents, and flood-frequency return periods tend to rise in the latter half of the 21st century under high-emissions conditions.[52]

3. Relevant Data Sources

Flood Hazard Data

National Flood Risk Index

The Indonesian National Disaster Management Agency's Indeks Risiko Bencana Indonesia (IRBI)

provides a transparent, municipality-level measure of flood susceptibility based on observed inundation characteristics, terrain features, recurrence patterns, and local coping capacity. IRBI is therefore useful for establishing a baseline understanding of present-day spatial flood exposure across Indonesia. However, because IRBI is an observational index and does not incorporate forward-looking climate scenarios or physical-hazard evolution, it cannot be used to derive future hazard trajectories required for scenario-based financial analysis. For this reason, IRBI is referenced only to contextualise Indonesia's current risk landscape, rather than as an input into the model. For initial work in flood risk exposure mapping under IRBI scoring, please see Appendix 1.

Flood Hazard Projections in S&P Trucost Data

In contrast to IRBI's present-day, municipality-level profiling, the S&P Trucost physical-risk dataset (Trucost) provides forward-looking flood-hazard projections built on CMIP6 global climate models and aligned with IPCC's Shared Socioeconomic Pathways (SSP2-4.5, SSP3-7.0, and SSP5-8.5). These projections estimate how flood severity is expected to evolve from 2030 through 2090 under different climate pathways, incorporating changes in precipitation extremes, hydrological cycles, and surface-water dynamics. The dataset is scenario-driven rather than observational and does not measure realised flood conditions. Instead, it represents modelled hazard intensification under climate change. A distinguishing feature of the Trucost framework is that hazard projections are computed for the precise latitude–longitude coordinates of corporate facilities, which allows for greater accuracy.

Climate-Financial Impact Data

Asset-level Financial Impact

The site-level hazard estimates in Trucost are then processed through its proprietary impact-

function, which translates flood severity into indicative operational downtime, repair and replacement costs, and business-interruption pressures for different asset types, using more than 250 asset-type–specific impact functions considering the vulnerability of each asset and business activity. These asset-level components feed into Trucost's internal modelling and are not implemented separately in this study.

These impacts are modelled separately for fluvial (riverine), pluvial (extreme-rainfall), and coastal floods, under the CMIP6 Representative Concentration Pathways (RCPs) aligned with Shared Socioeconomic Pathways (SSPs) SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5 scenarios. Financial impacts are expressed as percentage annualized loss of asset value (covering capital, operational, and business-interruption pathways) induced by the specific type of flood at the forecast year, with decadal projections extending from 2020 to 2090.

Company-level Financial Impact

The asset-level impacts are aggregated onto the **company level**, following company structure in Trucost database. Company-level impacts are assessed using aggregated assumed asset values and, where full coverage is not available, geographic-revenue weighting or country-average estimates.

Our analysis relies on this final output of Trucost physical risk modelling. This dataset quantifies the expected economic consequences of climate-related hazards for over 18,000 companies worldwide. The modelling combines projected hazard-intensity changes with sector-specific impact functions capturing how floods affect capex repair requirements, operational cost structures, and revenue disruption.

Although these results represent indicative rather than precise loss estimates, they enable consistent cross-company comparisons of flood-related vulnerability across scenarios and time horizons.

Figure 27 Loan Portfolio Coverage by Trucost
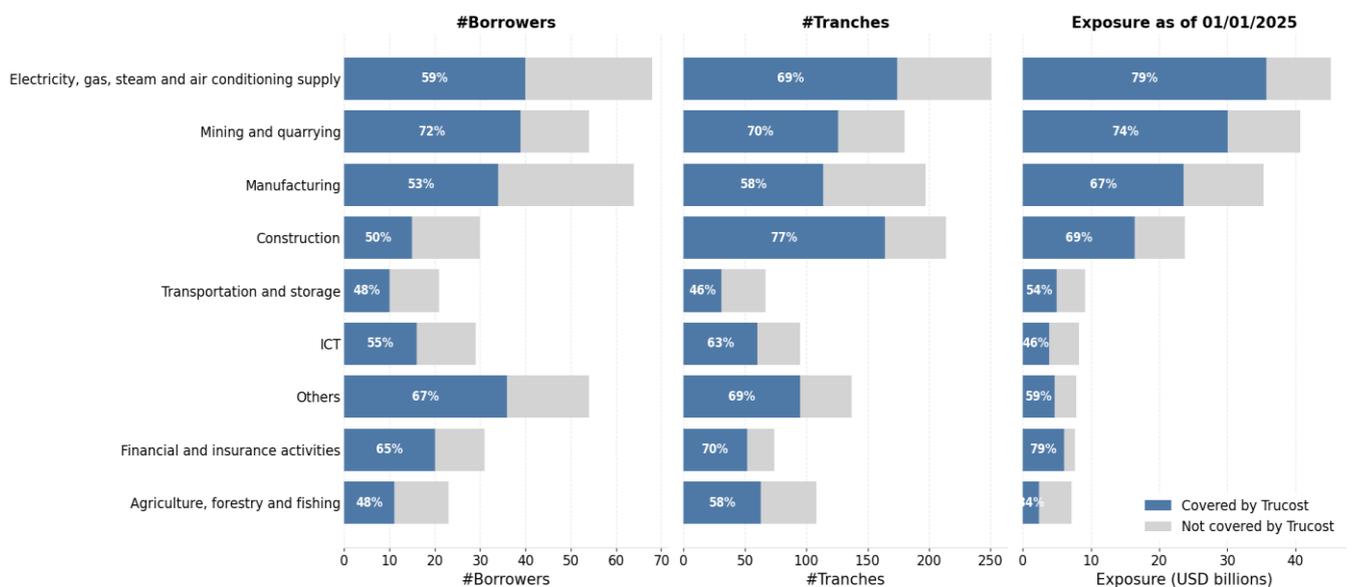
Data Coverage

As shown in Figure 27, in our reconstructed loan portfolio, banks are exposed to 374 borrowers as of January 2025, out of which 221 (**59%**), covering **69 percent of the total exposure**, have company level quantified financial-impact estimates for flood- related hazards. Larger borrowers tend to be better covered in Trucost, which also applies to sectors with a few dominant borrowers such as electricity, mining and manufacturing. The electricity sector achieves the highest coverage in Trucost because it covers PLN which is the largest borrower in our dataset.

Sectors such as agriculture shows better coverage in number of borrowers rather than the amount of exposure, implying disproportionately sparse coverage on larger borrowers. In particular, Trucost does not provide flood-induced financial impact for PalmCo, the largest agriculture borrower in the reconstructed portfolio.

4. Methodology

Physical climate hazards are spatially localized, whereas banks are exposed to risk at the portfolio level. The methodological framework therefore adopts a bottom-up aggregation strategy that maps borrower-level projected asset losses into portfolio-level, exposure-weighted risk measures. The framework characterizes how heterogeneity in borrower-level physical impacts, when scaled by credit exposure, gives rise to differences in risk distribution, and scenario-dependent loss trajectories at the portfolio level.

Portfolio-level projected asset loss

Annualized projected portfolio flood-induced asset loss, hereafter referred to as projected asset loss, for bank j at forecast year t under climate scenario cs is defined as the mean of borrower-level projected asset losses, weighted by loan exposure:

$$P_{j,t,cs} = \sum_{i=1}^{N} \omega_{i,j} \, X_{i,t,cs},$$

where $\omega_{i,j}$ denotes borrower i's share in the total credit exposure of bank j at time t, and $X_{i,t,cs}$ denotes borrower i's annualized projected flood-induced asset loss at forecast year t under scenario cs. The projected asset losses are obtained from S&P Trucost.

Our physical risk analysis focuses on each bank's loan portfolio composition as of January 2025 and adopts a static portfolio assumption. Under this assumption, balance-sheet positions are held fixed and no endogenous portfolio reallocation, hedging, or changes in credit supply take place over the analysis horizon. While this abstraction does not capture dynamic balance-sheet adjustment, it is useful in stress-testing and risk-mapping exercises to isolate the exposure to physical risk embedded in observed bank loan portfolios. By conditioning on the existing portfolio composition, the analysis captures the cross-sectional allocation of physical risk at a given point in time, without confounding the results with hypotheticals about future lending behaviour, strategic portfolio adjustments, or policy-driven reallocation of credit.

Measurement of borrower-level flood impacts

Borrower-level projected asset losses are obtained from S&P Trucost's physical risk estimates of annualized asset loss associated with three flood hazard types: fluvial, pluvial, and coastal flooding. The three hazard types are treated as mutually exclusive, and total flood-induced asset loss is defined as the additive sum across the three categories.

S&P Trucost provides projections at the firm level, derived from asset-level hazard and vulnerability assessments using proprietary methodologies. Where borrower-level is unavailable on S&P Trucost, projected asset losses are imputed using

averages of firms in the same NACE Level 2 industry category. This imputation approach compresses within-industry heterogeneity, but it preserves full portfolio coverage in the analysis and avoids systematic exclusion of borrowers without direct model estimates.

Scope conditions and limitations

The proposed physical risk framework is subject to several scope conditions. Firm-level physical risk estimates rely on observable asset locations and may not fully capture all subsidiaries or geographically dispersed operations. Borrower coverage is constrained by the availability of credit information in our reconstructed loan portfolio, implying that private firms and non-syndicated exposures may be underrepresented. In addition, the analysis focuses exclusively on flood hazards and does not account for interactions with other physical climate risks. Accordingly, the results should be interpreted as indicators of relative exposure, concentration, and sensitivity patterns within the observed loan portfolios rather than precise estimates of realized financial losses.

Portfolio risk metrics

To characterize the distributional properties of projected asset losses within bank loan portfolios, the framework constructs a set of exposure-weighted risk metrics capturing loss thresholds, sectoral composition of extreme losses, and exposure concentration to system-level high-impact borrowers. All metrics are computed using the static 2025 loan portfolio snapshot and are intended to support comparative analysis across banks, bank groups, and sectors.

Exposure-weighted loss thresholds

For each bank j, exposure-weighted loss thresholds are computed at selected quantiles of the borrower-level loss distribution, including the median, the interquartile range (25th to 75th percentiles), and upper-tail thresholds (95th and 99th percentiles). Each threshold represents a borrower-level projected asset loss such that the specified share of the bank's total credit exposure is associated with borrowers experiencing losses at or below that level.

For each bank j, exposure-weighted loss thresholds are computed as weighted quantiles of the borrower-level projected asset-loss distribution, using each borrower's credit exposure share as the weight. Specifically, the q-th exposure-weighted threshold is the loss level $L_j(q)$ such that borrowers with projected losses at or below $L_j(q)$ account for q of the bank's total credit exposure (e.g., $q = 0.50$ for the exposure-weighted median). We report central and tail thresholds, including the exposure-weighted median, the interquartile range (25th and 75th percentiles; $L_j(0.25)$ and $L_j(0.75)$), and upper-tail cutoffs (95th and 99th percentiles). These thresholds therefore summarize how projected losses are distributed across exposure (instead of the number of borrowers), providing an interpretable mapping from projected loss levels to the fraction of the loan book associated with losses up to those levels.

Sectoral composition of extreme losses

The sectoral composition of extreme tail risk is examined by decomposing projected asset losses within the upper tail of each bank portfolio's distribution of borrower-level losses. The upper tail is defined as borrowers whose projected asset losses meet or exceed the 95th-percentile loss threshold. Sector-level contributions to tail loss are then computed as the share of total upper-tail losses attributable to these borrowers in each sector.

Exposure to system-wide high-impact borrowers

To capture concentration in system-wide extreme exposures, borrowers are ranked across the full universe of bank loan portfolio based on their projected asset losses $X_{i,t,s}$. For each bank j, exposure concentration to system-wide high-

impact borrowers is then defined with respect to the top q percent of system-wide high-impact borrowers where $q \in \{1,5,10\}$). Specifically, this measure captures the share of a bank's total credit exposure that is concentrated in borrowers belonging to the top q percent of the system-wide loss distribution:

$$T_{q,j,t,s} = \sum_{i \in \text{Top } q\%} \omega_{i,j} \, .$$

This metric measures the extent to which a bank's portfolio is exposed to borrowers that are most severely impacted in absolute terms across the banking system, rather than characterising the tail of the bank's own loss distribution.

Loss trajectories and escalation under climate scenarios

To assess the dynamic evolution of physical risk under alternative climate pathways, we construct climate-scenario-specific loss trajectories using projected asset losses at selected long-horizon forecast years. These trajectories allow losses to be tracked consistently across scenarios and over time, thereby capturing both the level and the progression of physical risk under increasingly severe climate conditions. In doing so, the approach provides a transparent mapping between scenario severity, time horizon, and projected loss outcomes.

Scenario-specific loss trajectories are constructed using projected asset losses $P_{j,y,cs}$ at forecast years $y \in \{2060,2070,2080,2090\}$ under climate scenarios $cs \in \{\text{SSP2-4.5, SSP3-7.0, SSP5-8.5}\}$, which span a

range of physical risk intensities (Riahi et al, 2017). Loss escalation is then defined as the incremental change in projected asset losses between the early and late forecast horizons,

$$\Delta P_{j,cs} = P_{j,2090,cs} - P_{j,2060,cs}.$$

This measure provides a concise measure of the long-run amplification of physical risk under each climate scenario. By focusing on the change between 2060 and 2090, it isolates the contribution of climate change over time while abstracting from short-term fluctuations, thereby enabling systematic comparisons of physical risk accumulation across banks and climate pathways.

5. Results

Magnitude of Flood-induced Asset Loss Across Bank Portfolios

The results in Figure 28 show that across all banks, the exposure weighted-average of annual projected loss due to flooding hazards for the borrowers would be 0.45 percent of their asset value, at 2060 checkpoint under the baseline SSP2-4.5 scenario. This metric is hereafter referred to as **projected asset loss**. The projected asset loss for four **large domestic commercial banks is at 0.4 percent** (Mandiri, BNI, BCA, and BRI). Most banks with more diversified portfolio show results of similar range. It should be noted that the precision of these projections remains contingent upon the quality and comprehensiveness of the data provided by our external data sources.

Figure 28 Projected Asset Loss at 2060
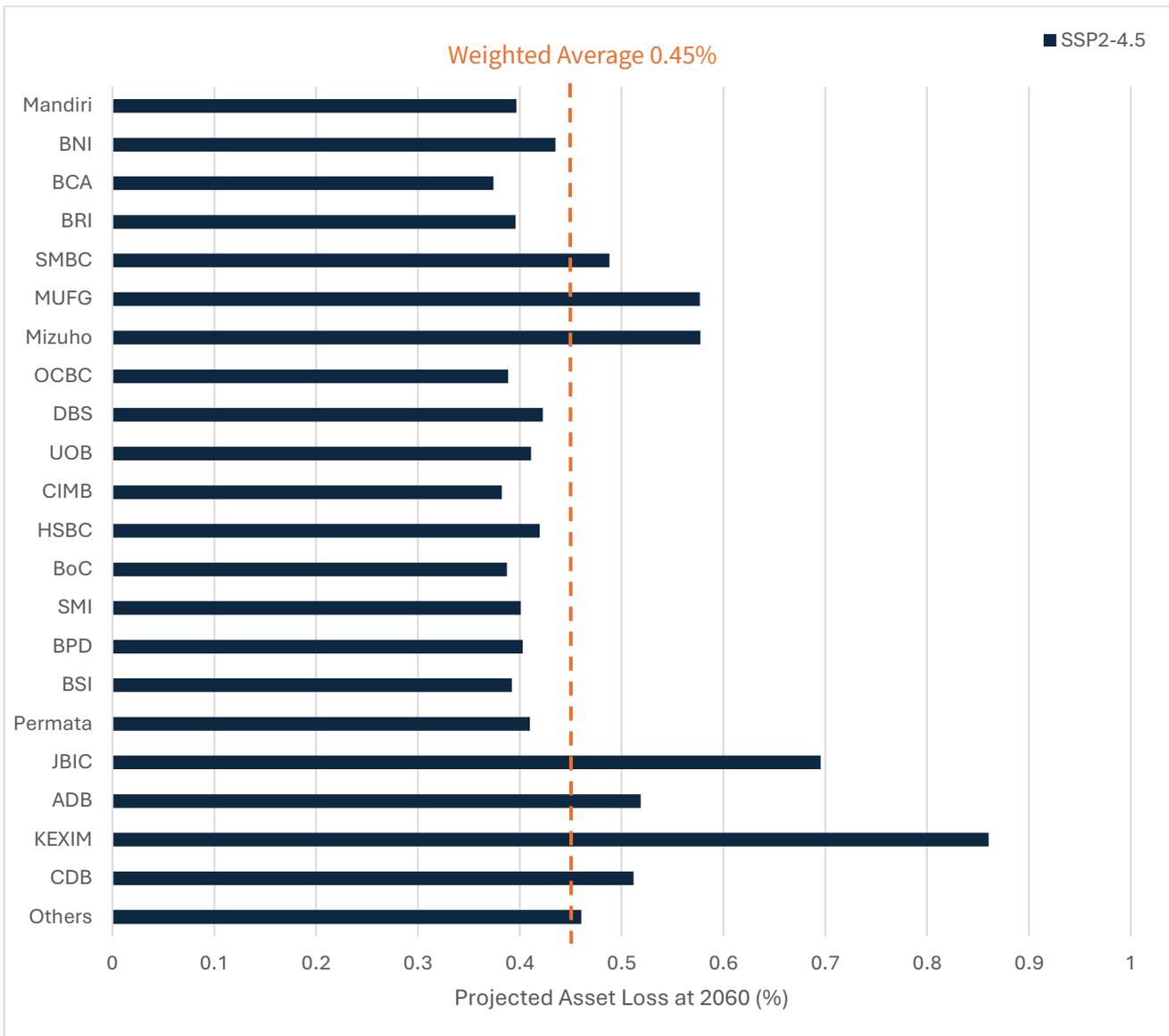
For banks, the level of projected asset loss signals recurring physical disruptions that could diminish the operational performance of asset-intensive borrowers, such as those in the electricity or the mining sectors, and eventually their ability to repay the debt. Small reductions in asset functionality can translate into larger effects on earnings before interest, tax depreciation, and amortisation (EBITDA), as firms face higher maintenance and repair costs, lower utilisation of facilities and equipment, and interruptions to production. This erosion in operating earnings may weaken borrowers' interest-coverage ratios (ICR) and reduce their debt repayment capability and capacity to absorb future shocks.

From a credit-risk perspective, sustained pressure on earnings and cash flow can increase the probability of default (PD), particularly for borrowers operating with thin margins or high leverage. Physical damage to assets that also serve as collateral may limit recoverable value, placing upward pressure on loss given default (LGD) in the event of default.

In addition, flood events would also reduce the value of loan collaterals, further damaging the borrower's credit quality and its ability to repay

the loan in full. This analysis assumes that asset losses are fully absorbed by the banks, unmitigated by insurance coverage or firm capital. Assuming a pass-through effect from asset loss to reduction in debt payment, the 0.4 percent effect would substantially affect the banking sector's viability, potentially reducing the banking sector's Return on Asset **(ROA) by 10-20 percent** from its baseline [d] and its Return on Equity **(ROE) by around 270 bps**[e].

Comparing the impact on most banks, especially among the large domestic commercial banks, we do not observe a meaningful difference in flood-induced asset loss with their portfolio by 2060 under the baseline scenario. This may reflect similar levels of geographical diversification among the largest lenders in Indonesia's banking system.

By contrast, foreign lenders such as Japanese commercial banks and DFIs whose exposures are concentrated in fewer projects – typically in electricity and mining sectors – would experience higher sensitivity to flooding hazards. Under SSP2–4.5, these lenders show approximately **0.1 percent to 0.3 percent higher** projected asset loss compared to other lenders.

Distribution of Flood Risk Across Bank Portfolios

While the banks exhibit relatively similar exposure to flood, we observe significant variation in the distribution of exposures within their portfolios.

To capture the distribution of exposures within each bank portfolio, we calculate the exposure-weighted dispersion of flood-induced annual asset loss across all borrowers in each bank's portfolio. For a portfolio with borrower-level

projected asset loss x_i for borrower i, the weighted average asset loss for bank j is $\mu_j = \sum_i w_{i,j} x_i$, where $w_{i,j}$ reflects the fraction of bank j's loan book allocated to borrower i. The exposure-weighted dispersion metric is then defined as the weighted standard deviation, expressed as $\sigma_j = \sqrt{\sum_i w_{i,j}(x_{i,j} - \mu_j)^2}$. This formulation ensures that borrowers with larger credit allocations exert proportionally greater influence on the dispersion metric, providing a summary indicator of how unevenly physical risk is distributed within a bank's portfolio.

Figure 29 shows the **dispersion of flood risk** within each bank's portfolio. The four large domestic commercial banks show similar average exposure (in Figure 28), but the dispersions of exposures in Mandiri's and BNI's loan portfolios are **almost double** of those of BCA's and BRI's loan portfolios. Bank Mandiri's dispersion of 0.3 percent under SSP2-4.5 indicates that the flood-induced asset losses of borrowers in a bank's portfolio deviate from the portfolio's average impact 0.4 percent (as shown in Figure 28), by around 0.2 percent, i.e., ranging 0.2 percent to 0.6 percent +/- one standard deviation. In practical terms, this indicates a moderate degree of heterogeneity in physical-risk exposure across Mandiri's loan book: some of its borrowers face materially higher flood-related losses than the portfolio average, while others experience lower impacts. The range of potential outcomes is smaller for BCA and BRI. For Mandiri, its higher dispersion highlights an uneven vulnerability within its loan portfolio, with a subset of loans potentially contributing disproportionately to physical-risk transmission under adverse climate scenarios.

[d] Bloomberg Terminal data (2024). Across the four largest domestic commercial banks, Return on Assets (ROA) ranged from 1.94% to 3.94%. The 10–20% reduction cited is relative to this baseline.

[e] Based on 2024 averages for these institutions (ROA: 2.84%; ROE: 19.46%). The derived equity multiplier of 6.85x implies that a 0.4 percentage point (40 bps) decline in ROA results in a ~2.7% decline in ROE.

In general, banks whose portfolios exhibit higher projected asset losses, such as Japanese commercial banks and DFIs, also show higher dispersions. Singaporean commercial banks portfolio (OCBC, UOB, DBS) also exhibits higher dispersions than their large domestic Indonesian peers, although they have roughly similar projected asset losses. This indicates that the

Singaporean banks' portfolios tend to include a small number of highly exposed borrowers along with a broader set of relatively less exposed ones. As a result, the underlying loss distribution can be more uneven, leading to higher dispersion, even when the average level of projected asset losses is comparable to that of domestic banks.

Figure 29 Dispersion of Projected Asset Loss within Bank Portfolios at 2060
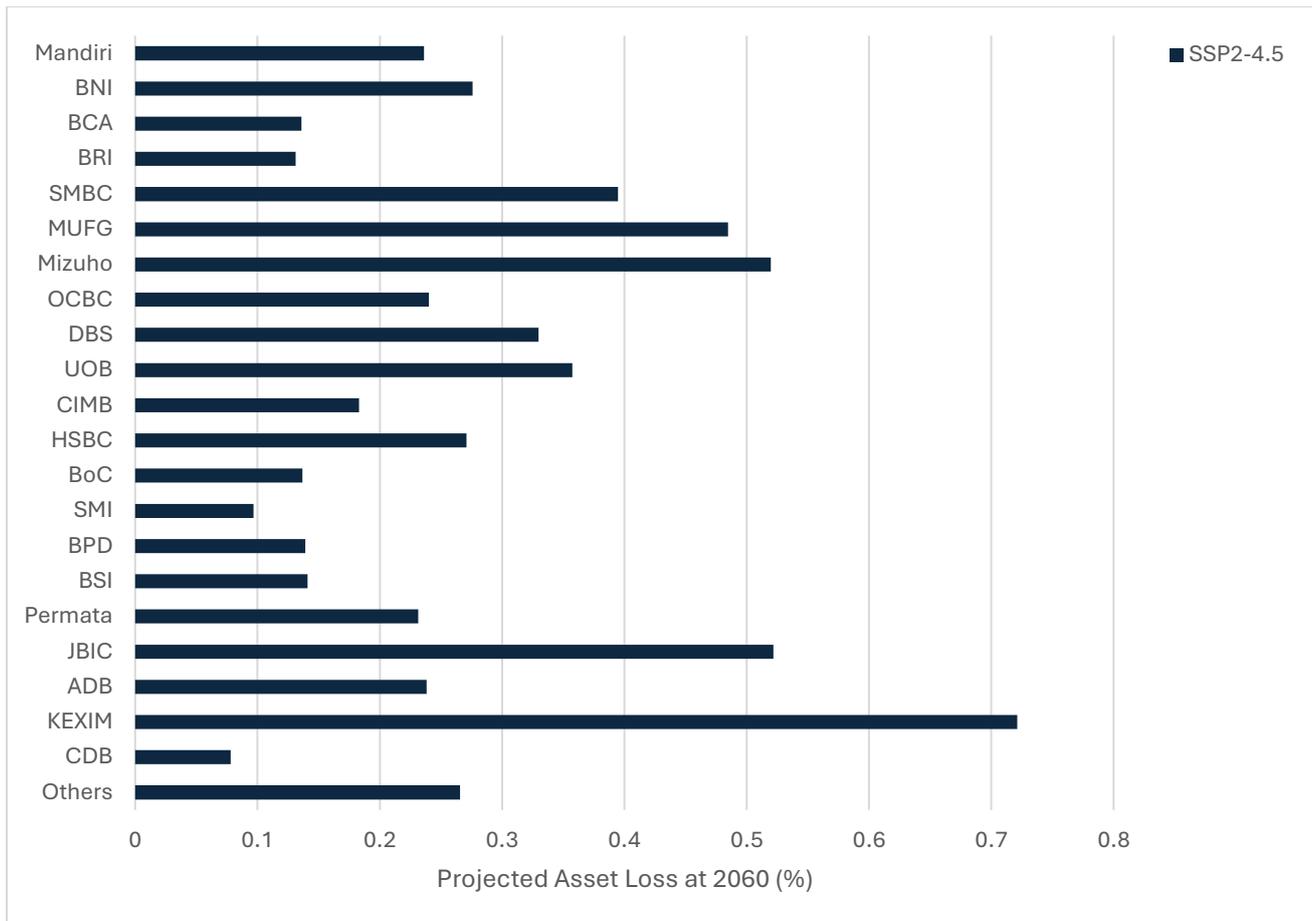
Sectoral Contribution to Dispersion

To evaluate which sectors drive the dispersion of flood-induced financial impacts within each bank's portfolio, we decompose the portfolio-level dispersion into its sectoral components. For a given bank, following the previous denotation, the portfolio variance is defined as $\sigma_j^2 = \sum_i w_{i,j}(x_{i,j} - \mu_j)^2$. The contribution of industry sector s to the portfolio variance of bank j is computed as $C_{s,j} = \sum_{i \in s} w_{i,j}(x_{i,j} - \mu_j)^2$ and the

sector s's share of total variance of bank j's portfolio is $\frac{C_{s,j}}{\sigma_j^2}$. This decomposition attributes the overall dispersion in flood-induced asset loss to various sectors, based on both the size of exposures to each sector and the extent to which borrower-level asset losses in that sector deviate from the portfolio average.

Figure 30 Sectoral Contribution to Variance, SSP2-4.5, 2060
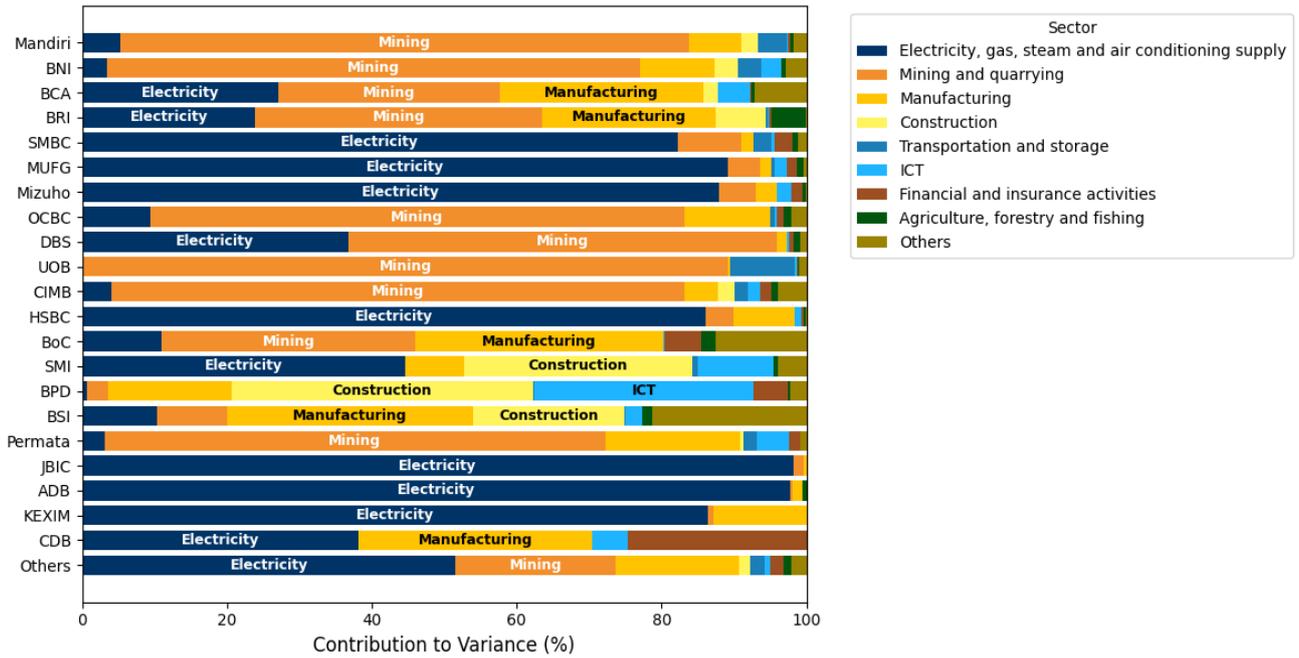
As shown in Figure 30, **mining and electricity** sectors contribute to most of the dispersion in most banks' portfolios, followed by construction and manufacturing sectors. These patterns indicate that these sectors are correlated with the flood risk based on their assets' geolocations and business activities. Among the large domestic banks, the dispersions in asset-level risks for **Mandiri and BNI** are largely contributed by borrowers in the mining sectors. In contrast, **BCA and BRI** have wider distributions of outliers beyond the mining sector, with the electricity and manufacturing sectors contributing almost equal proportion to the variance as the mining sector.

In Figure 9 on page 13, the four large domestic commercial banks do not exhibit significant difference in sectoral composition. Hence, the differences in sectoral contributions to projected loss variance in Figure 30 are driven by differences in obligor-level concentration at different geolocations with varying flood exposures.

Exposure to Top Flood Impacted Borrowers

Figure 31 provides another perspective on portfolio's exposure to the top impacted borrowers. Across a universe of 221 borrowers in the Indonesia banking system as of January 2025 with coverage in the Trucost database, we sort them according to their flood-induced asset loss projected under SSP2-4.5, in 2060. The top 1 percent, 5 percent and 10 percent of these borrowers' exposure with the highest projected flood impact are labelled in red, orange and yellow, respectively. The vertical-dotted lines indicate the average share of exposure that a typical bank would allocate to each of these groups.

Among the domestic banks, Bank Mandiri's portfolio approximates the system average, with exposure to the top 1 percent and 5 percent flood-exposure borrowers close to the benchmark lines. BCA and BRI have no exposure to the top 1 percent group, consistent with their relatively lower dispersion in Figure 29. In contrast, BNI shows higher exposure **(~7.2 percent)** to the top 5 percent borrowers. This likely contributes to the bank's higher mean impact and dispersion observed earlier in Figure 28 and Figure 29, respectively.

Several foreign commercial banks exhibit larger-than-average exposure to the top 1 percent of highly impacted borrowers, in particular the Japanese banks. This is likely to reflect their participation in a small number of large projects located in flood-prone regions, such as the Cirebon coal-fired power plant and Harum Nickel operations. Similar, albeit weaker, patterns are also observed in the loan portfolios of UOB (for the top 5 percent group) as well as DBS and HSBC (for the top 1 percent). DFIs also tend to exhibit higher exposure to the top 1 percent, consistent with their focus on large, capital-intensive projects.

Figure 31 Exposure to Top Impacted Borrowers, , SSP2-4.5, 2060
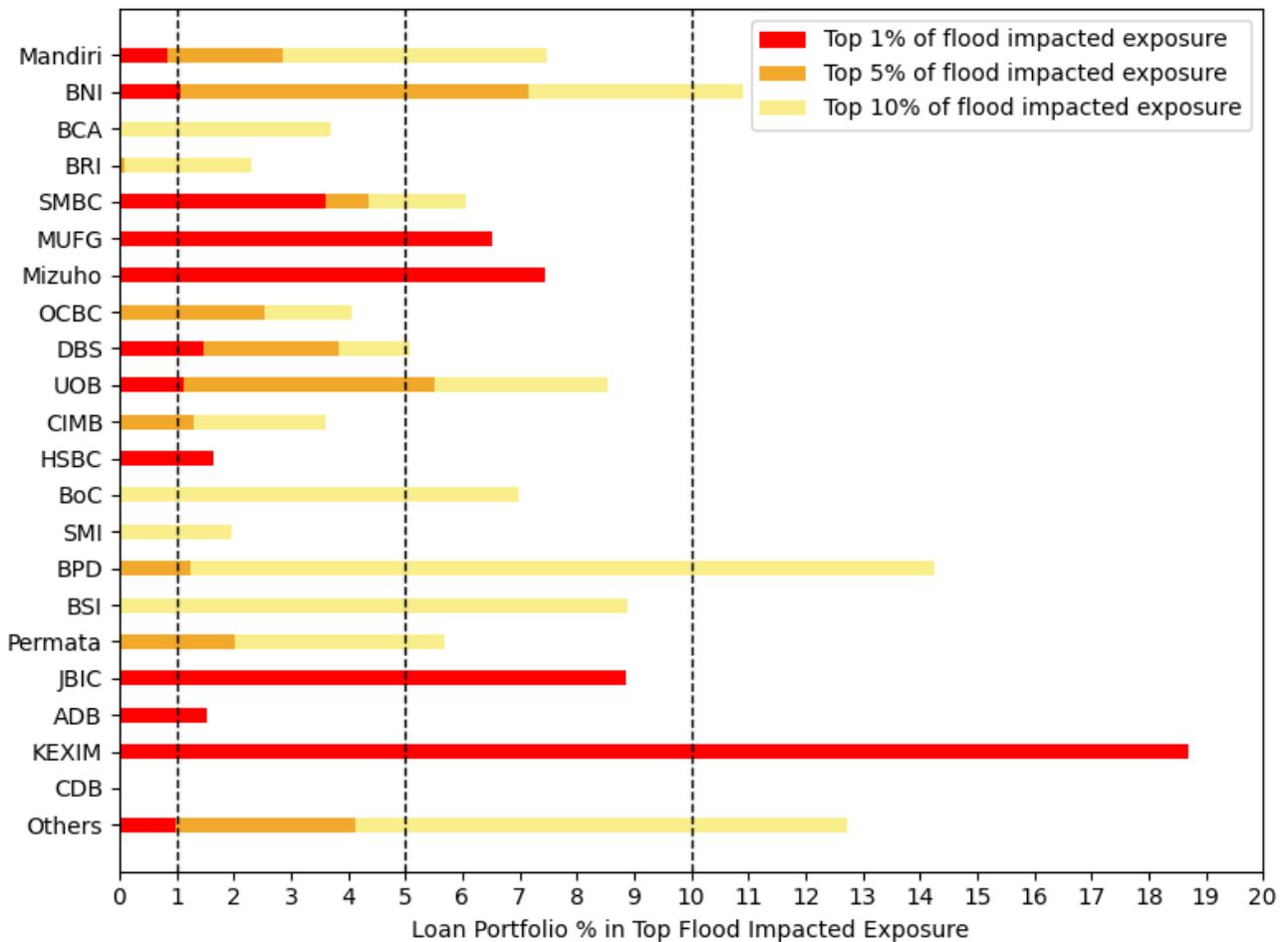
Distribution of Extreme Flood Impacts Within Bank Portfolios

Another graphical representation of the data is provided in Figure 32, which presents the full distribution of borrower-level annual flood-induced asset loss projected under the SSP2-4.5 scenario. The medians across banks cluster around similar levels, however the distribution in the upper tail differs substantially. For the large domestic banks, the interquartile ranges are relatively compact, but their 95th-percentile values diverge. BNI and Mandiri show **higher tail impacts** compared with BCA and BRI, indicating that a small subset of borrowers in their portfolios faces more elevated flood losses.

The 99th-percentile markers reach approximately 2.4 percent for many banks. This value implies that roughly 1 percent of the bank's exposure is associated with borrowers projected to experience at least 2.4 percent flood-induced asset loss in 2060 annually. The identical extreme values across various banks likely reflect the fact that several highly exposed projects are jointly financed by multiple lenders, leading to common tail observations across portfolios even when their overall structures differ.

Foreign commercial banks and DFIs generally exhibit wider right tails, driven by a small number of loan exposures with elevated impacts. Japanese banks and DFIs display longer 75th-percentile whiskers and higher 99th-percentile values, consistent with earlier findings on greater dispersion in impacts and concentration. In contrast, most domestic banks, such as Mandiri, BCA, and BRI, typically exhibit shorter tails, indicating fewer borrowers with potentially extreme impact within their portfolios.

Overall, the chart highlights that cross-bank differences arise primarily from the upper tail of the distribution of potential impacts rather than from differences in medians or typical borrowers.

Figure 32 Distribution of Projected Asset Loss Across Banks, SSP2-4.5, 2060
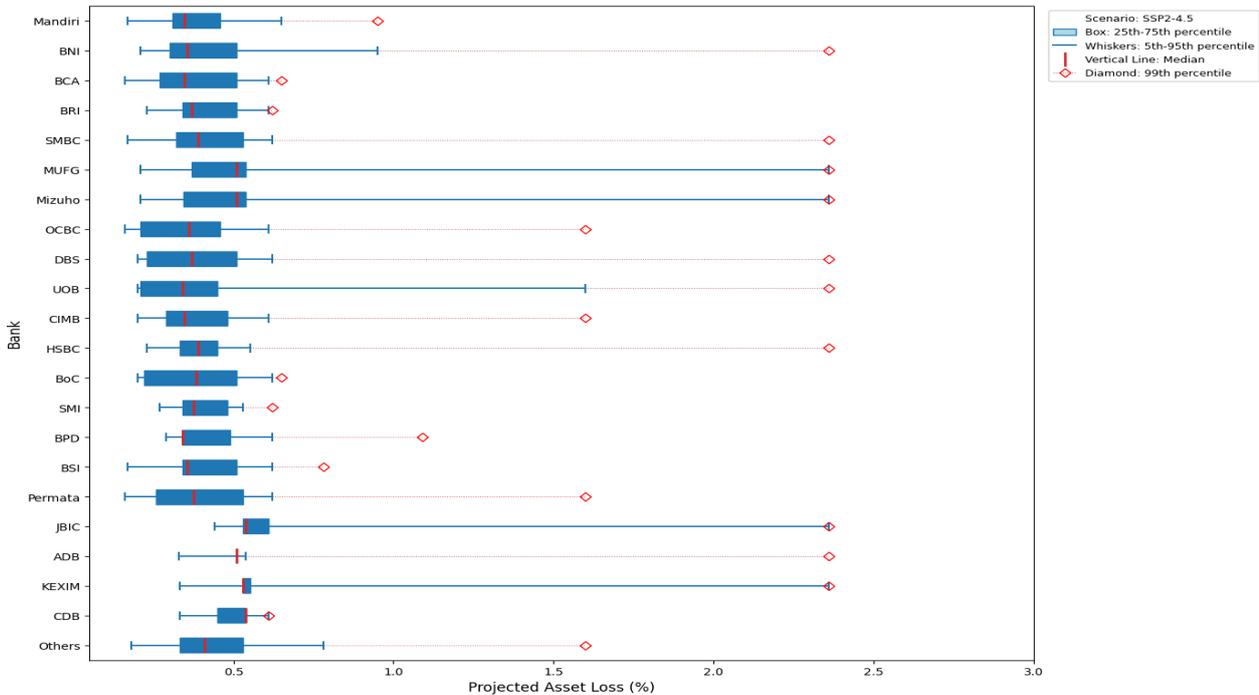
Composition of Tail Loss

Figure 33 shows the **sectoral composition** of the borrowers that make up the top 5 percent tail of projected asset losses for each bank. This tail corresponds to the borrowers at or above the right whisker in the Figure 32. For each bank, the bars display the percentage contribution of each borrower to the total projected asset losses generated by this tail group, ranked from the largest contributors on the left to the smallest on the largest contributors on the left to the smallest on

the right. Each borrower is color labelled by their respective sectors.

To illustrate the patterns, let us examine Bank Mandiri (the top bank in the Figure). For Mandiri, the tail consists of 10 borrowers whose projected annual flood-induced asset loss meets or exceeds approximately 0.95 percent, as illustrated in Figure 32. Within these 10 borrowers, mining companies account for more than 88 percent of the total tail loss, followed by losses in

Manufacturing and other smaller sectors. This indicates that Mandiri's most flood-impacted borrowers are concentrated in a small number of mining-related projects.

We observe large variations across banks in sectoral contribution. For Japanese banks, Singaporean banks, and DFIs, almost the entirety of the tail loss is driven by one or two sectors: **mining** (dark orange) and/or **electricity** (dark blue).

Across many banks, these two sectors are the dominant contributors to tail loss, frequently appearing in the leftmost segments of the bars. In contrast, smaller domestic banks, such as BPDs and BSI, are exposed to higher projected asset losses contributed by the construction sector (yellow).

Figure 33 Tail Loss Composition: Individual Borrower Contribution to 95th Percentile Loss, SSP2-4.5, 2060
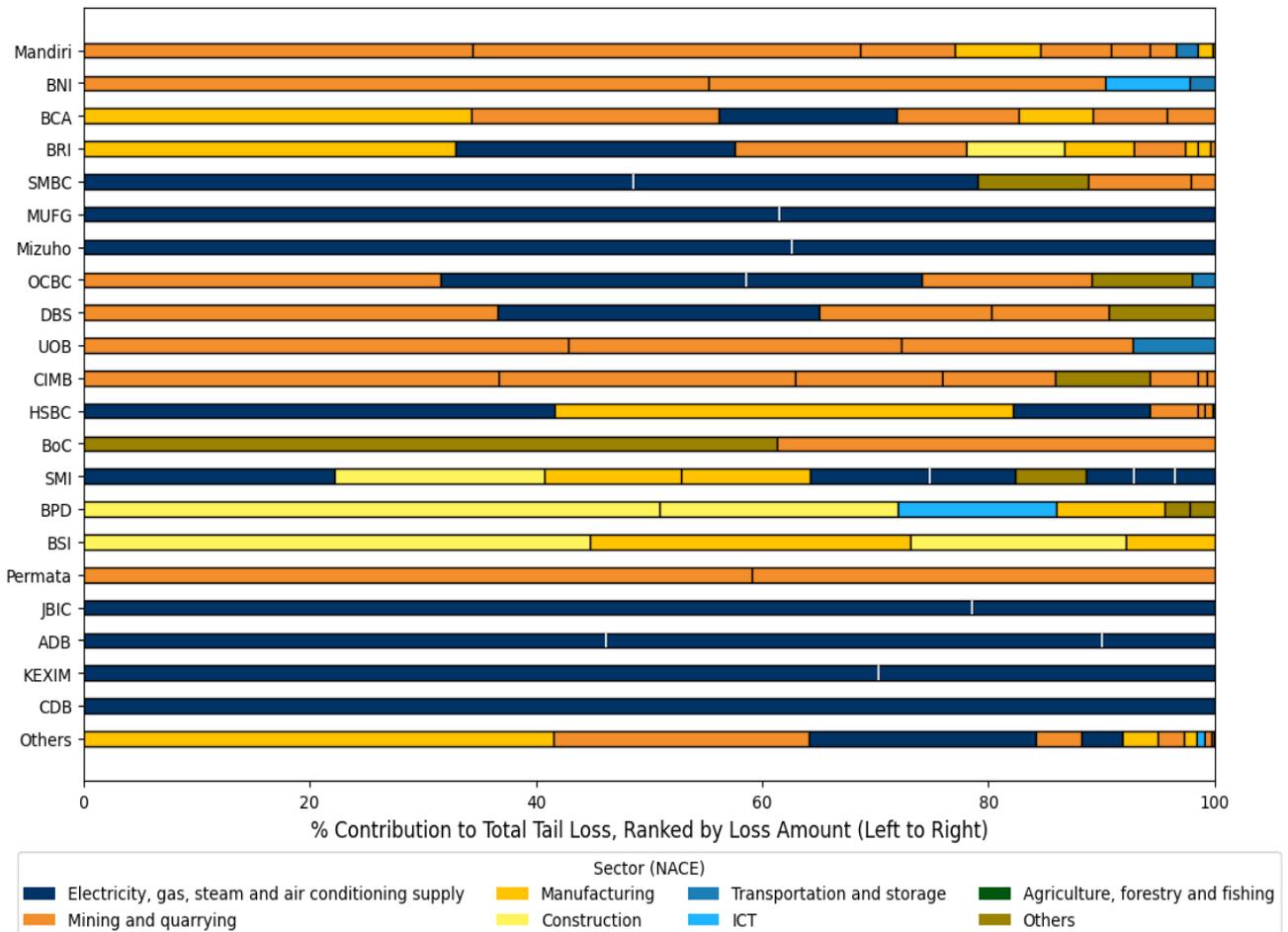
Sensitivity under Severe Scenarios

The analysis in preceding sections assumes a baseline of the SSP2-4.5 emission scenario, which largely represents the current global emission pathways. However, if mitigation efforts do not strengthen meaningfully, flood risks will manifest as significantly heightened asset losses under more severe pathways.

As shown in Figure 34, the average of **additional** projected asset losses for banks' portfolio is **14 bps** as the world moves to the SSP3-7.0 scenario and **30 bps** towards the more severe SSP5-8.5 scenario. Under SSP5, the projected asset losses will translate to 8-15 percent further reduction in ROA and 2 percent further reduction in ROE. These increments are in addition to the respective baseline impacts shown in Figure 28 (which averaged 0.45 percent).

For most banks, these additional losses appear proportional to their baseline risk, as projected by Trucost. The **interbank comparison** patterns in Figure 34 closely mirror those in Figure 28. Essentially, institutions with higher baseline exposure are projected to experience the most significant additional losses under severe scenarios.

Focusing on large Indonesia domestic commercial banks, the additional projected asset loss averages **27 bps** when moving from SSP2-4.5 to the **"hot-house world"** of SSP5-8.5. Under these adverse conditions, the divergence between bank portfolios widens. For instance, under SSP5-8.5, the gap between **BNI** and **BCA** increases by an additional **8 bps**, adding to the **7-bps difference** already present in the baseline scenario in Figure 28.

Figure 34 Additional Projected Asset Loss from SSP2-4.5 to SSP3-7.0/5-8.5, 2060
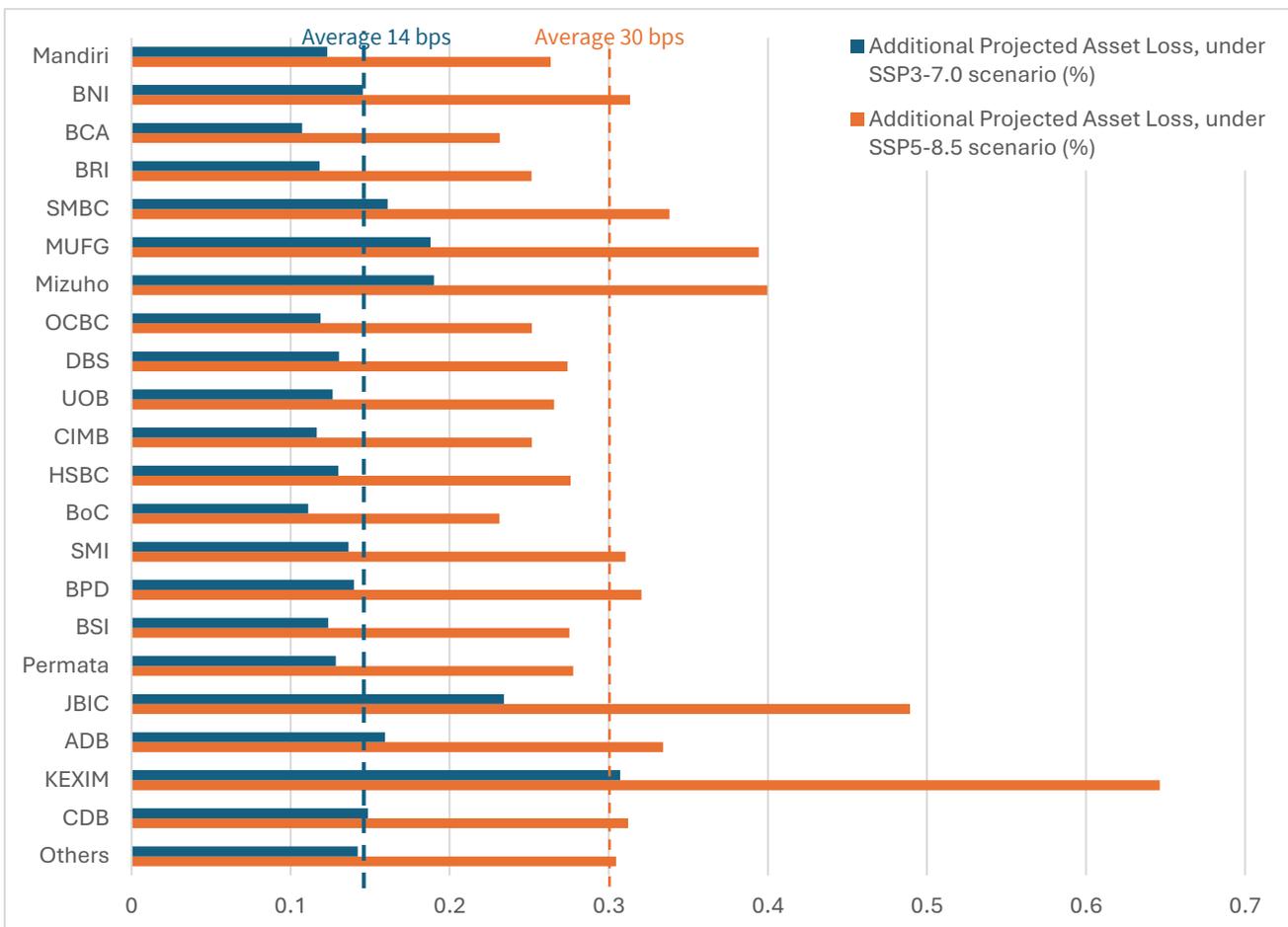
The **dispersion** of projected asset losses also expands as emission pathways deteriorate. Figure 35 captures this **additional dispersion** as the climate outlook worsens. Under SSP5-8.5, BNI is projected to see a **0.30 percent increase in dispersion** compared to the baseline (with an average impact 0.43 percent +/- 0.28 within 1 standard deviation). Given that the magnitude of

this additional dispersion is comparable to the baseline figures in Figure 29, the **standard deviation** under SSP2 essentially doubles under SSP5. Consequently, banks with higher existing portfolio dispersion will likely face an even sharper contrast in performance between their resilient and high-risk assets.

Figure 35 Additional Dispersion in Projected Asset Loss from SSP2 to SSP3/5, 2060
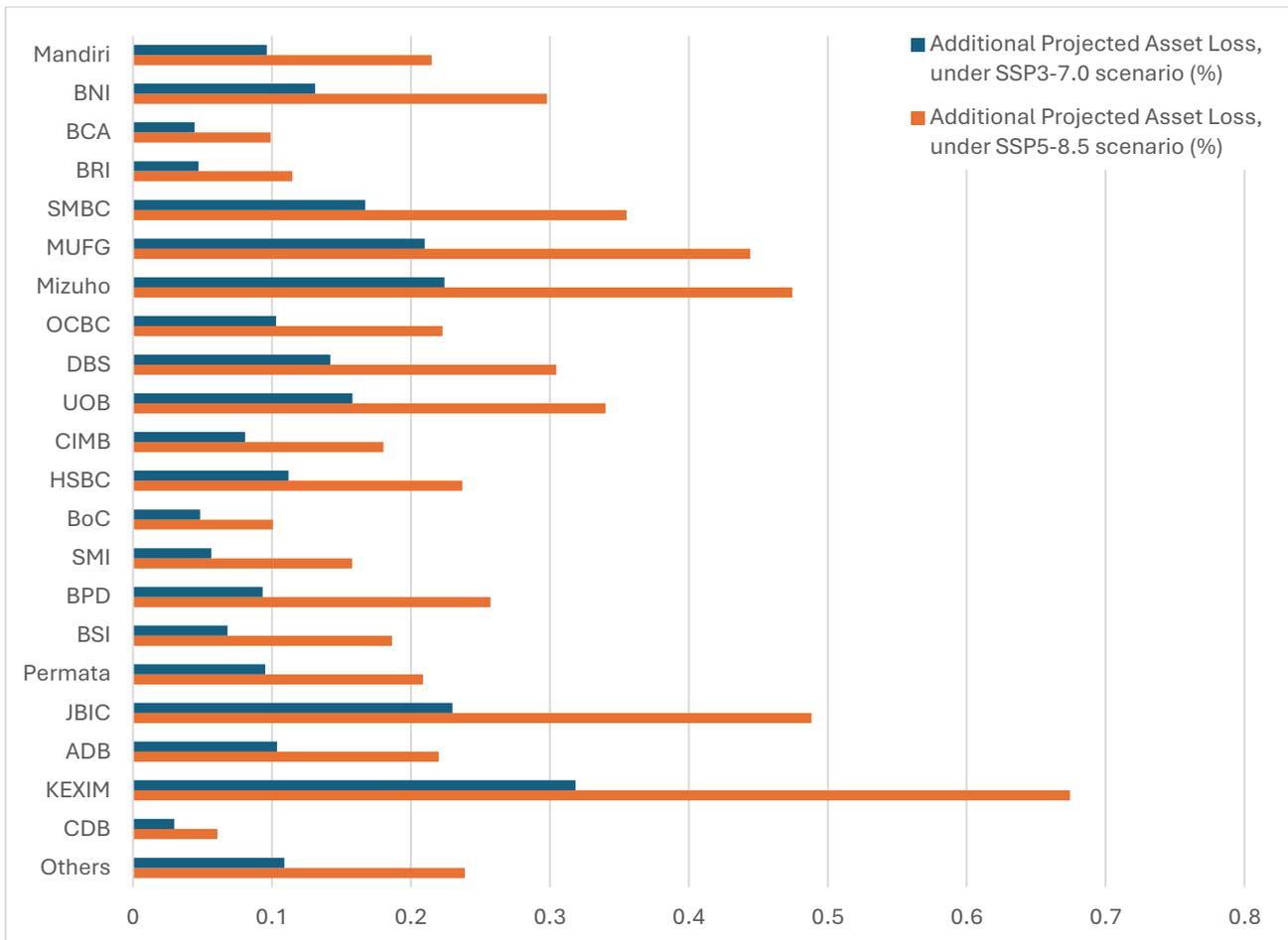
Future Trajectories under Different Climate Scenarios

We have so far focused on the flood-induced projected asset loss at the 2060 horizon. With physical hazards evolving over time rather than manifesting only at a single checkpoint, it is useful to examine how projected impacts increases over an extended period.

Figure 36 document flood-induced projected asset losses for the underlying borrowers from

2020 to 2090 across three climate scenario pathways. The upper bound and lower bound of the shaded areas represent the 25-percentile and 75-percentile asset losses projected for the major lenders (smaller lenders are aggregated under "Others").

Under SSP2-4.5 pathway, the increase is gradual, remaining below **1 percent until around 2080 and reaching just under 2 percent by 2090**. Under worse climate scenario pathways, SSP3-7.0

and SSP5-8.5, the trajectory steepens noticeably after 2050, with projected asset losses surpassing **3 percent** by the end of the century in SSP5-8.5 pathway. The projected asset losses are about **61 percent higher** in 2090 under this scenario than under the baseli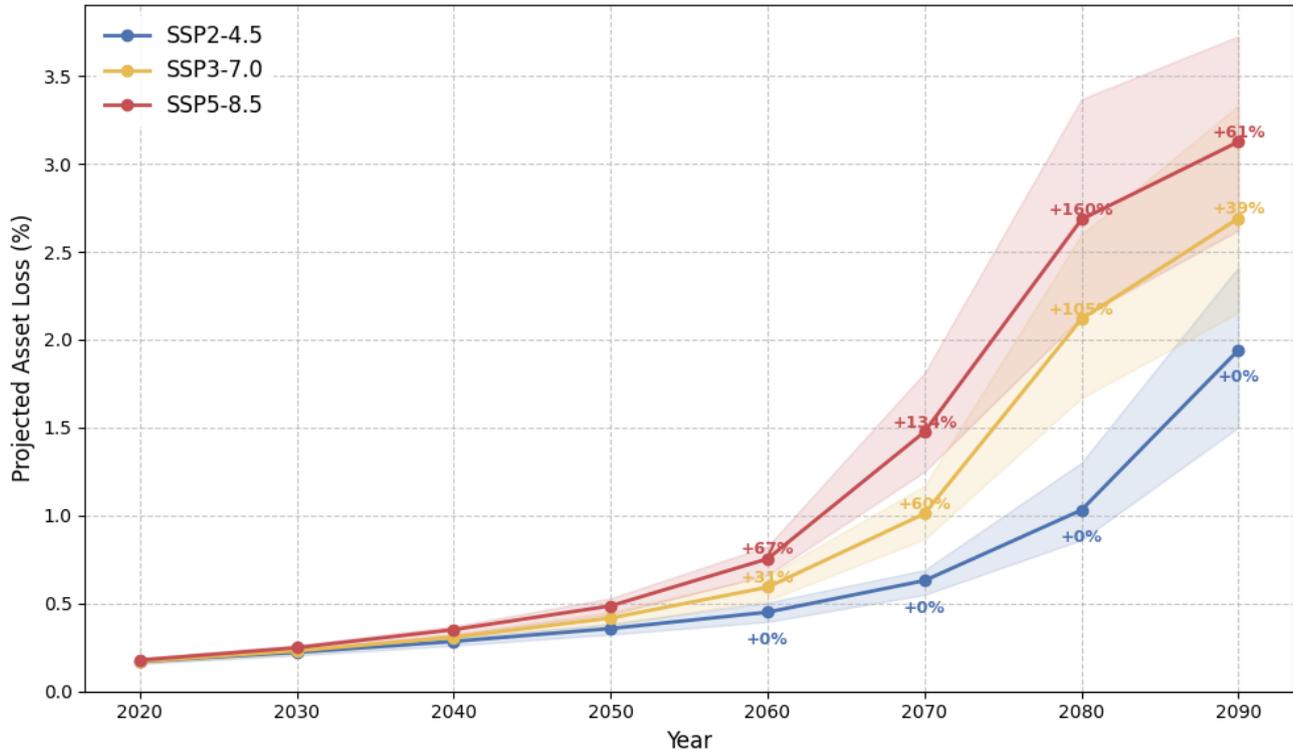ne SSP2-4.5 scenario. Under all three scenarios, the spread between the banks widens towards 2090, implying a greater significance in physical risk management to potential flood-induced losses.

Figure 36 Projected Asset Loss Trajectory under Different Climate Scenarios

Future Trajectories by Sector

Figure 37 illustrates how flood-induced asset loss evolves across sectors under the baseline SSP2-4.5 scenario. The risk appears to be systematic. Across the sectors, financial and insurance are the least impacted due to their traditionally light asset and infrastructure nature, projected to lose about **0.6 percent** asset value annually by 2090.

Although all sectors experience rising impacts over time, the increase is relatively gradual up to mid-century. By 2070, coal and electricity sectors are the most affected. The inset highlights the mid-century period, where the divergence across sectors becomes more visible, with coal and electricity sectors consistently leading other sectors. Manufacturing and mining (including coal) sectors are also among the most heavily impacted.

After 2070, the trajectories begin to diverge more sharply. **Construction and electricity** sectors exhibit the **steepest rise toward 2090**, followed by coal and manufacturing sectors, while agriculture, ICT, and financial services experience comparatively moderate growth in projected losses. The mining sector, despite its earlier leading position, will be surpassed by other sectors in terms of projected losses. These patterns underscore that long-horizon physical risks are uneven across sectors, with energy and infrastructure-intensive industries becoming increasingly exposed as climate hazards intensify.

Figure 37 Projected Asset Loss Trajectory for Sectors under SSP2-4
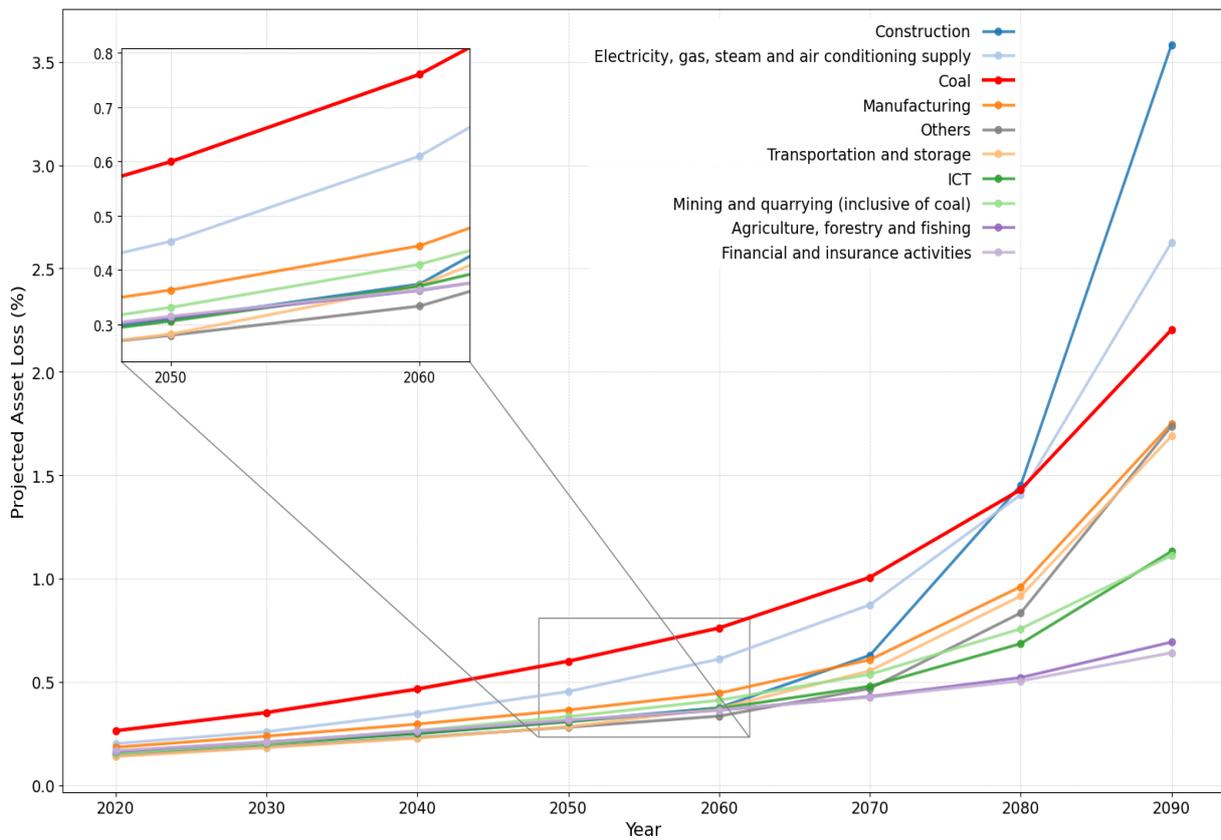
Figure 38 illustrates that as emission pathways shift from current pledges toward a hot-house world scenario, high-impact sectors—including construction and electricity—experience a sharp acceleration in projected asset losses. This escalation is particularly pronounced starting in 2080, a decade earlier compared with the leftmost SSP2-4.5 panel, where the loss curves steepen significantly before beginning to plateau.

In the rightmost panel, the "black dot" markers represent the incremental increase in projected asset losses from 2060 to 2090 under the SSP2-4.5 scenario. The "white dot" markers indicate the corresponding increment under the more severe SSP5-8.5 scenario. The electricity sector exhibits the highest sensitivity to deteriorating pathways.

It is projected to face an **additional 1.6 percent** annual asset loss by 2090 in the high-emission future. The hot-house world scenario also exerts substantial pressure on the construction and coal sectors.

Notably, even the financial and insurance sectors, which appear less affected under current pledges (NDC), show a scenario-based difference of 0.5 percent. Given that the baseline escalation under SSP2-4.5 is relatively low (~0.28 percent), the SSP5-8.5 pathway effectively **triples the baseline projection** for these sectors. This underscores that even traditionally "safer" sectors are not immune to the risks of deteriorating climate pathways.

Figure 38 Projected Asset Loss Trajectory for Sectors from SSP2-4.5 to SSP5-8.5

Figure 39 Projected Asset Loss Trajectory for Bank Portfolios under SSP2-4.5

Note: DFIs refer to JBIC, ADB, KEXIM, and CDB. Japanese Commercial Banks are SMBC, MUFG, and Mizuho. Large Domestic Commercial Banks are Mandiri, BCA, BNI, BRI. Singaporean Commercial Banks refers to OCBC, DBS, and UOB.

Future Trajectories for Banks

Figure 39 presents the evolution of projected asset losses across various lender groups under the current world SSP2-4.5 scenario. Up to around 2060, differences across banks remain relatively small, with all groups rising gradually to appr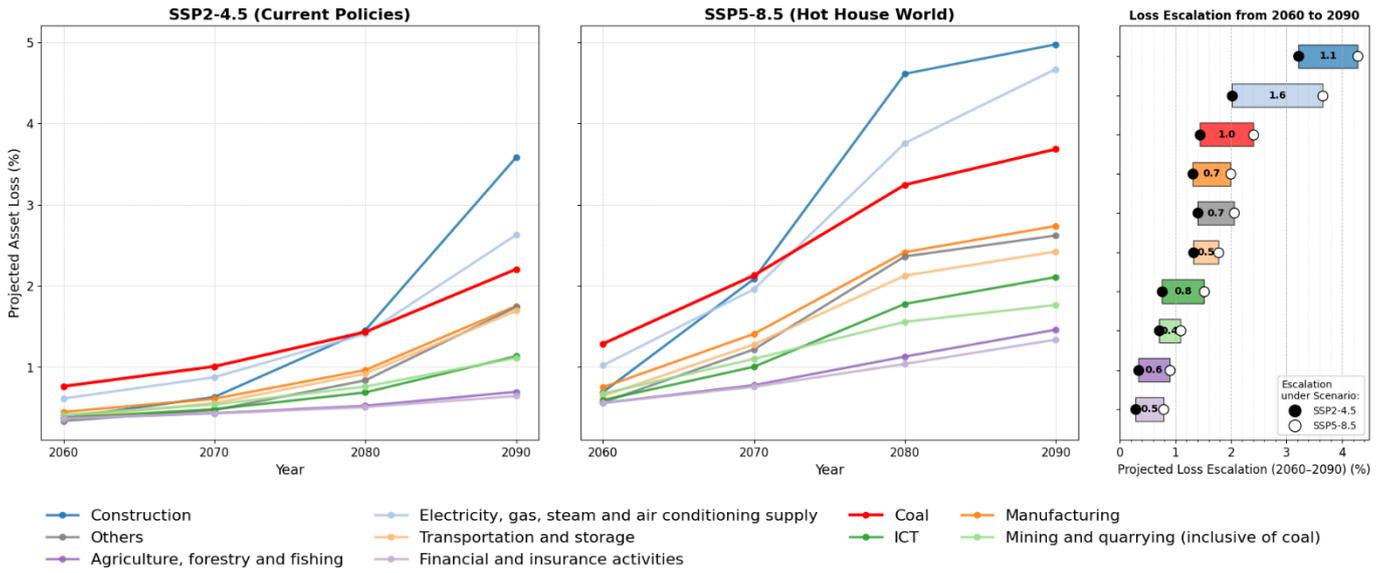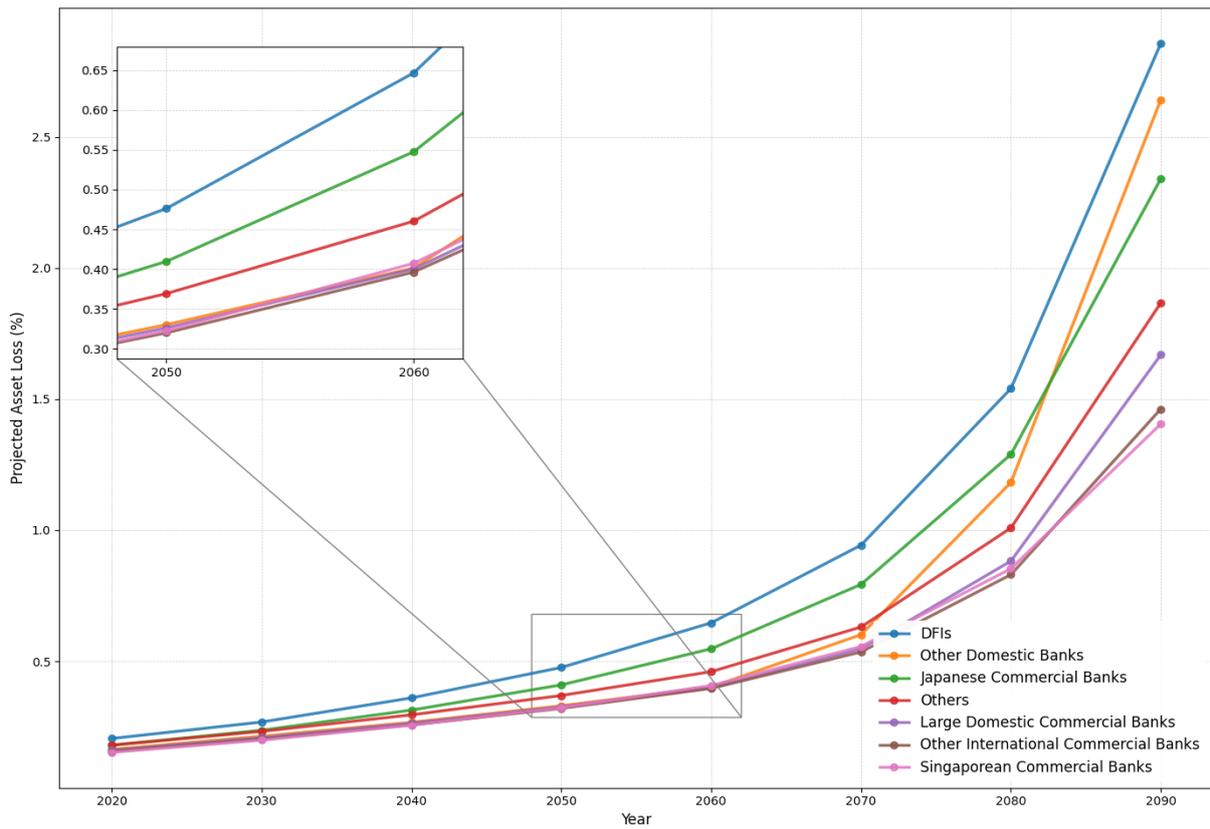oximately **0.4–0.65 percent**. The inset highlights this early period, where DFIs and Japanese commercial banks already sit slightly above other lenders, consistent with earlier observations of their higher mean impacts and greater exposure to upper-tail borrowers.

After 2060, the trajectories begin to diverge more clearly. Banks with higher concentrations in borrowers located in flood-prone regions, or in a few large projects with elevated physical impacts, see a steeper rise toward 2090. Large domestic commercial banks remain in the middle of the range. These differences are consistent with earlier results showing variation in tail exposures and portfolio volatility.

Figure 40 Projected Asset Loss Trajectory for Bank Portfolios from SSP2-4.5 to SSP5-8.5
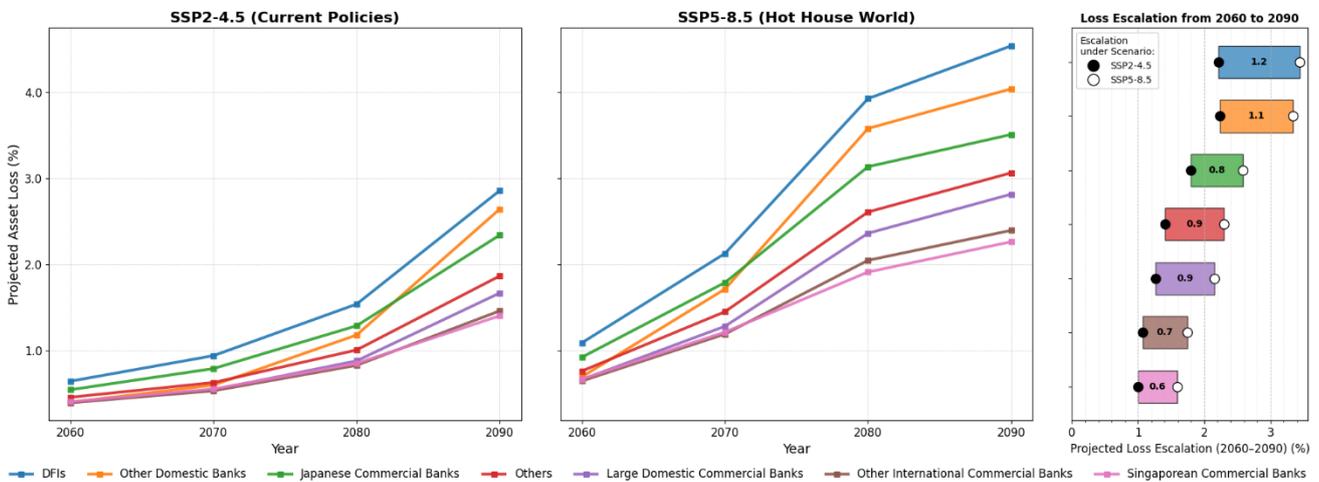
Figure 40 demonstrates that in a hot-house world scenario, the divergence in projected asset losses among large domestic banks, international commercial banks, and Singaporean commercial banks manifests a full decade earlier, becoming prominent by 2080. This acceleration is likely driven by the domestic banks' credit exposure to the construction sector. As established in Figure 38, the construction sector is projected to undergo the steepest escalation in asset losses post-2060. Consequently, large domestic banks and other domestic institutions exhibit significantly higher sensitivity to these deteriorating conditions compared to their Japanese and Singaporean counterparts.

A similar pattern to Figure 39 is observed when examining individual Indonesian domestic banks in Figure 41. The trajectories of BPD, SMI, BSI, BNI, Permata, Mandiri, BRI and BCA remain very close up to 2060 **ranging 0.38 percent-0.44 percent** (potentially 13-15 percent reduction from the baseline ROA, and 260- 301 bps reduction in ROE), reflecting similar aggregate exposure to physical risk at this horizon. Beyond 2070, the curves diverge as differences in exposures to vulnerable borrowers and sectors begin to shape long-horizon outcomes more strongly. Banks with more diversified borrower bases, such as Mandiri, BRI and BCA, show comparatively flatter paths, while other domestic banks exhibit steeper rises.

Figure 42 further illustrates that under the SSP5-8.5 (Hot House World) scenario, the relative ranking of projected asset losses among the selected banks remains stable compared to the

baseline. However, the magnitude of divergence between institutions shifts significantly. Specifically, the loss differentials between BNI, Mandiri, BCA, and BRI contract under the more severe pathway, suggesting a "convergence of risk" as extreme climate physical hazards affect a broader base of assets.

The rightmost panel provides a deeper look at scenario sensitivity, revealing that banks with lower baseline risks are not necessarily the most resilient to deteriorating conditions. **BCA and BRI exhibit higher sensitivity** to climate scenarios than Mandiri and BNI; this is evidenced by the wider "Scenario Gap" in their escalation boxes (values of 1.1 and 0.9 respectively, potentially translating to approximately 39-32 percent reduction in ROA from its baseline and 750-650 bps reduction in banks' ROE). While Mandiri and BNI face higher absolute losses, their loss escalation is more consistent across scenarios. In contrast, the rapid expansion of losses for BCA and BRI under SSP5-8.5 indicates that their portfolios may contain "tipping point" assets that are disproportionately impacted by a shift from current pledges to a hot-house world.

Figure 41 Projected Asset Loss Trajectory for Indonesian banks under SSP2-4.5
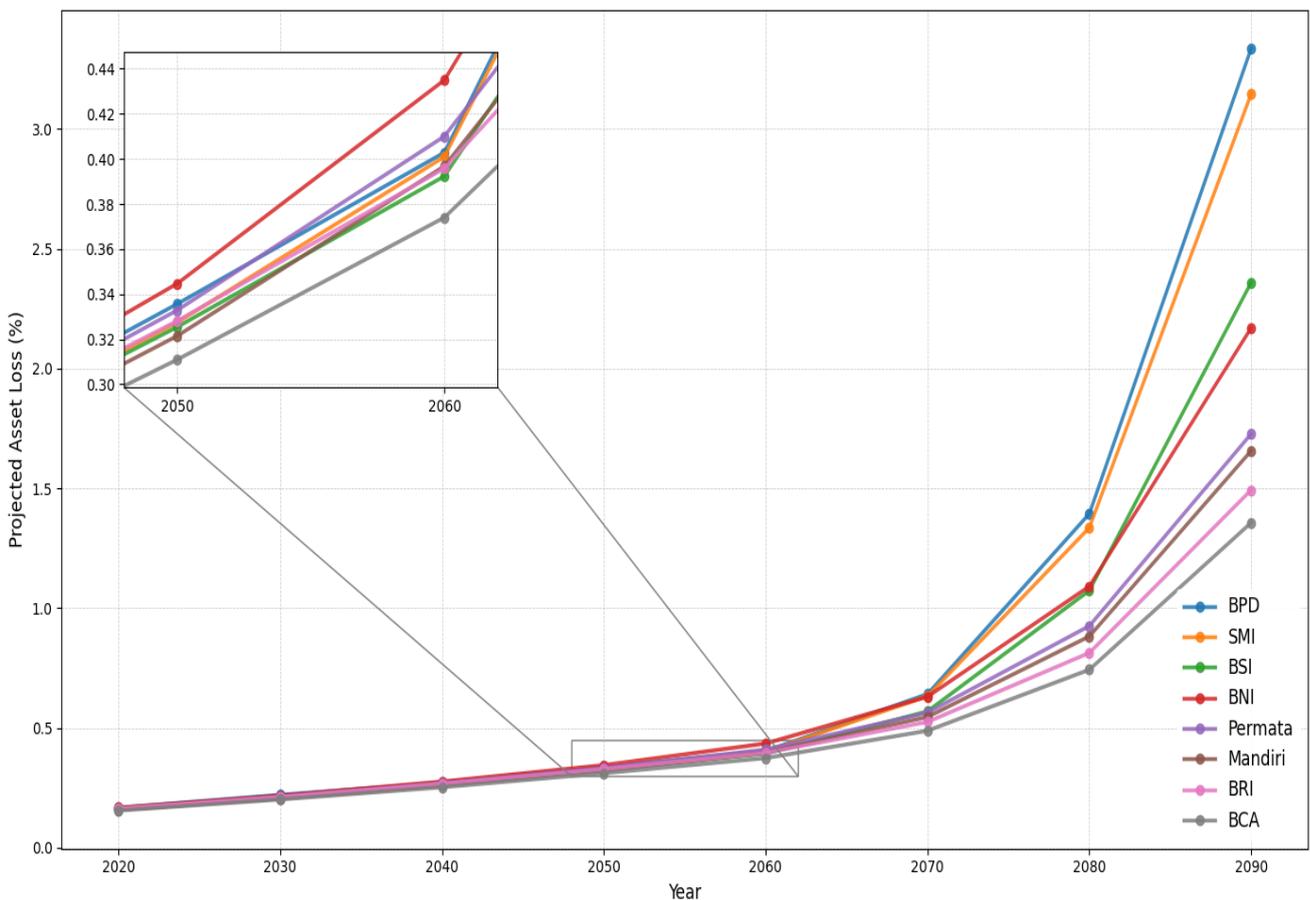
Figure 42 Projected Asset Loss Trajectory for Indonesian banks from SSP2-4.5 to SSP5-8.5
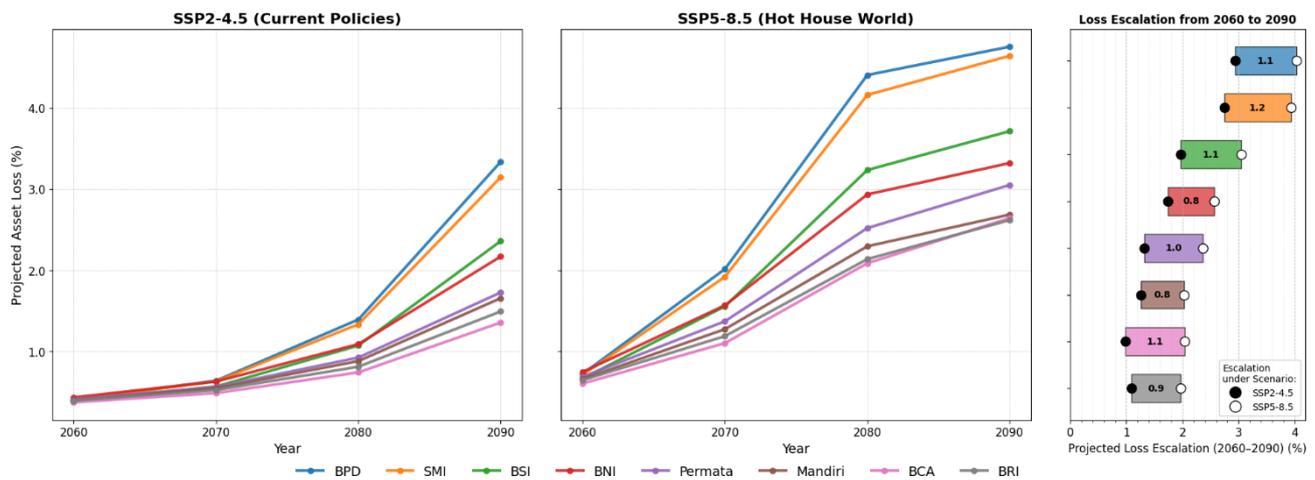
A comparison across the large domestic commercial banks, as shown in Figure 43, reveals that the diverging trajectories of these institutions **(a)** cannot be fully explained by sectoral composition **(b)** alone. Although the four banks maintain relatively similar portfolio compositions, BNI (projected with the highest losses) and BCA (projected with the least) exhibit a widening gap in their projected asset losses toward the end of the century.

The distinction between the two most impacted banks BNI and Mandiri and their peers BCA and BRI in **(a)** is supported by observations of their **risk distributions**. BNI and Mandiri possess more outliers within a single industry—mining **(c)**—which faces significant physical risk compared to other companies **(d)**. Within these bank portfolios, these mining outliers result in higher 95-percentile and 99-percentile tail risks **(e)**.

While these differences do not result in significant variations between portfolio averages by 2060, their effects become increasingly pronounced toward the end of the century as climate impacts intensify.

The SSP5-8.5 panel reinforces the danger of these outliers; in a "hot-house" world, these specific "tail-risk" assets cause BNI and Mandiri's losses to escalate much more steeply and much earlier

than their peers. While BCA and BRI show a more concentrated distribution with fewer extreme outliers **(d, e)**, their projected asset loss escalation remains comparatively lower in absolute terms.

For commercial banks, Figure 43 demonstrates to commercial banks that sector composition does not provide a complete picture of cross-bank variation. Instead, portfolio-wide outcomes are often skewed by a small number of large, flood-prone projects. While average impacts remain relatively stable until 2060, the presence of a limited set of highly vulnerable borrowers can still contribute substantially to overall portfolio stress. Strengthening physical-risk frameworks therefore requires moving beyond sector-level patterns to incorporate a granular focus on borrower-specific characteristics.

Figure 43 Projected Asset Loss Analysis for Large Domestic Commercial Banks

(a) Projected Asset Loss Trajectory
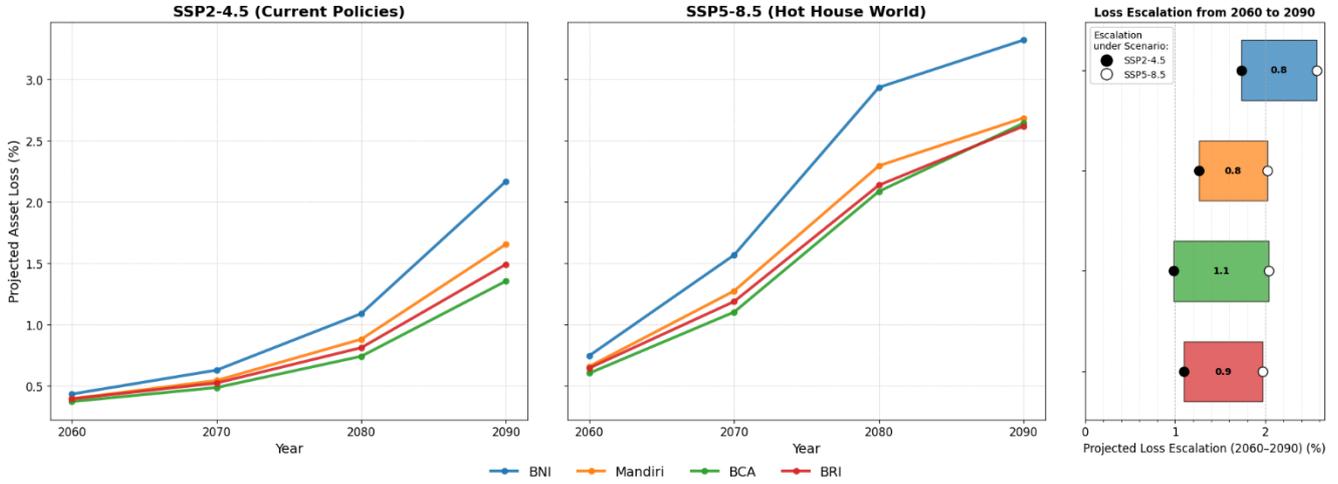
(b) Portfolio Composition by Sector
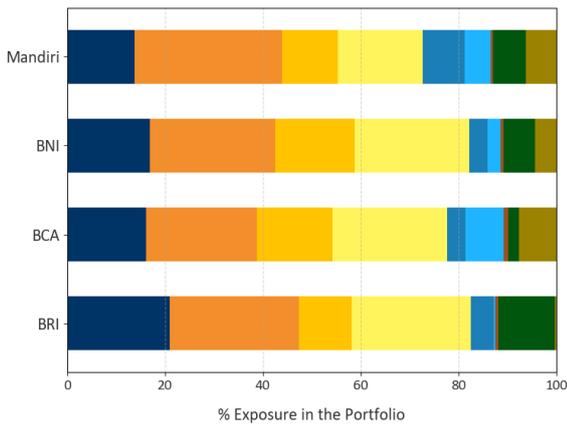
(d) Exposure to Top Impacted Borrowers
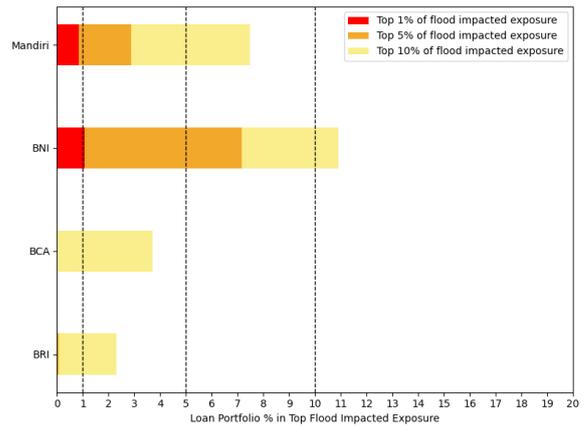
(c) Dispersion in Projected Asset Losses
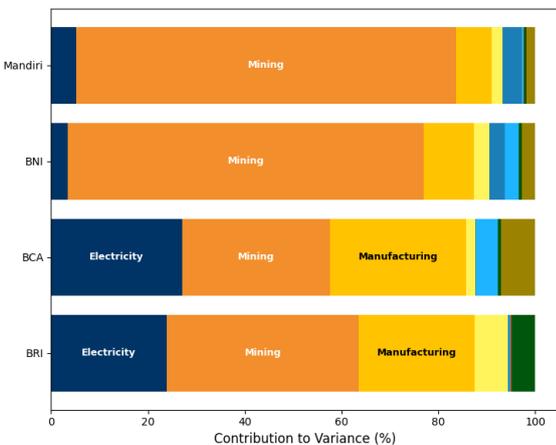
(e) Projected Asset Losses Distribution
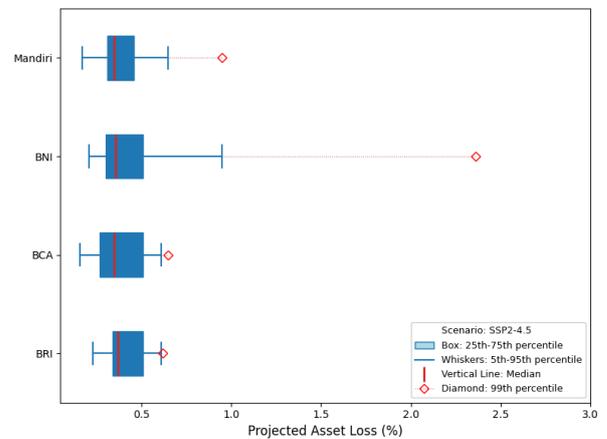
6. Findings

By 2060, most commercial banks face broadly similar levels of exposure-weighted flood-induced projected asset losses. For most banks including large domestic commercial banks, the projected asset loss average around **0.4 percent annually** under the SSP2-4.5 scenario for their Indonesian borrower portfolios, potentially translating to 2.7 percent reduction in ROE.

Under the worse SSP5-8.5 scenario, the projected asset losses will increase by **30 bps by 2060** (increase by **67 percent of the baseline value**), resulting in an additional 2 percent reduction in ROE.

While mid-century impacts remain relatively compressed across lenders, the differences widened progressively over the long horizon. Under more severe climate scenarios, the divergence becomes more pronounced toward the end of the century, reflecting how portfolio structure interacts with increasingly severe physical hazards. Banks with greater exposure to asset-intensive or coastal-proximate activities, including parts of the electricity, construction and mining value chains, tend to exhibit steeper increases in projected impacts over time.

If the world moves towards the hot house scenario, sectors and banks are projected to experience additional asset losses, each at different rates. Those that are more exposed to fossil-intensive sectors and construction sector are likely to see the additional loss rising earlier and higher than others.

However, sector composition alone does not fully explain cross-bank variation. The comparison among the large domestic banks illustrates that portfolios with similar sector shares can nevertheless display meaningfully different levels of dispersion, tail behaviour and long-horizon trajectories. **Differences in projected asset losses arise primarily from borrower concentration with a small number of highly impacted borrowers, which can disproportionately shape a bank's volatility, upper-tail loss and end-century projections.** This is evident in the contrasting patterns between Mandiri and BNI versus BCA and BRI, where similar sectoral allocations mask substantial variation in the presence or absence of highly exposed borrowers.

The analysis also highlights the role of shared large borrowers across banks. Several investment projects with elevated hazard profiles, particularly in electricity generation and mining, appear simultaneously in the upper tail of multiple portfolios, contributing to similar 99th-percentile values across banks despite otherwise distinct portfolio structures. This underscores that systemic exposures can arise through common financing of large, flood-vulnerable borrowers, not only through sectoral alignment.

In conclusion, the findings suggest that flood-related physical risk at the portfolio level reflects borrower-level risk amplified by correlated exposure to borrowers with elevated hazard and vulnerability characteristics, rather than sectoral characteristics. Concentration of credit allocation to such borrowers amplifies tail outcomes and steepens long-horizon trajectories under increasingly adverse climate pathways. These indicators provide useful diagnostics for identifying intersections between physical hazards and credit exposures as climate risks intensify.

Chapter V

Conclusion

V.   Conclusion

1.   Overall Results

Our analysis shows that in the corporate loan portfolios of Indonesian banks that we compiled, about one-third (33 percent) of loan exposures is concentrated in four large domestic commercial banks (Bank Mandiri, BNI, BCA and BRI). Across these banks, corporate credits are concentrated in emission-intensive sectors, such as electricity (24%), mining (22%), manufacturing (19%) and construction (13%). Moreover, these sectors exhibit high concentration in individual obligors, typically SOEs, with PLN as the single largest borrower (6.8 percent of the total exposure we compiled). Relative to these large domestic commercial banks, Japanese and Singaporean commercial banks have greater exposure to the electricity and the mining sectors, respectively.

Using the bank loan portfolios we compiled, we first conduct transition risk stress-testing of the Indonesian banking sector. In the carbon intensives sectors, we observe a relatively high volatility of Probability of Default (PD) of ~39 bps for the Oil and Gas sector, whereas the Coal and Electricity sectors exhibit volatilities of ~19 bps and ~16 bps, respectively. We perform the stress test by applying a 2-standard-deviation (2σ) increase of PD to each sector's base rates. With this 2σ shock, the expected loss for the overall bank loan portfolio in Indonesia across 2015 to 2025 is approximately 60-120 percent higher than the baseline, half of which can be attributed to the fossil-intensive sectors.

Beyond expected losses, it is critical to attribute the vulnerability to the two sector categories. For the fossil-intensive sectors, the expected loss intensity is estimated to increase by ~7-bps with the 2σ shock in 2025, which is significant relative to the base rate of ~20 bps. The loss intensity of the carbon-intensive loan exposures increased steadily since 2019, with a clear step-up in the post-2020 period and remaining elevated in recent years. Comparing across banks, Singaporean banks exhibit among the highest carbon-intensive loss intensity across the sample period, consistently above their low-carbon benchmark.

The physical risk analysis is developed using projected flood-induced asset loss estimates from S&P Trucost data. The analysis shows that the projected annual asset loss for most domestic commercial banks is around 0.4 percent at the 2060 checkpoint under the SSP2-4.5 scenario. Assuming a pass-through effect from asset loss to reduction in debt payment, the 0.4 percent effect would substantially affect the banking sector's viability, potentially reducing the banking sector's Return on Asset (ROA) by 10-20 percent from its typical level and its Return on Equity (ROE) by almost 3 percent.

If mitigation efforts are not strengthened sufficiently, under the hot house world scenario, these banks on average will experience an additional 27 bps increase in projected asset losses, potentially translating to a further 200-bps reduction in ROE. Overall, for all banks active in the Indonesian corporate banking sector, the projected asset loss will increase from its baseline by 67 percent at 2060 checkpoint under the more adverse SSP5-8.5 pathway.

The severity of these impacts is expected to intensify as the century progresses and climate conditions worsen. By 2090, the projected asset loss will reach approximately 2 percent under the baseline scenario and over 3 percent in the hot house world, potentially inducing a much higher reduction in ROE of the banking sector.

Ultimately, the degree of portfolio resilience will depend on the specific concentration of risk

within individual bank portfolios. Banks with more concentration on riskier projects and sectors are expected to experience approximately 0.1 percent to 0.3 percent higher projected asset loss compared to other banks. The difference in tail risk and dispersion will manifest to strong cross-bank differences as the century progresses and climate conditions worsen.

The magnitude of the estimated climate-risk amplification in this study is broadly in line with those reported in recent ECB climate stress-testing exercises[53], notwithstanding differences in modelling approaches. By and large, the estimated amplification in Indonesia exceeds ECB results, reflecting Indonesia's distinct policy environment, sectoral composition, and lower transition readiness relative to advanced European economies.

2. Implications & Recommendations

Indonesia's domestic transition pathway remains measured, reducing the likelihood of sudden, policy-driven credit shocks in the near term. This does not remove transition risks for the economy and for the banking sector. fossil-intensive sectors remain structurally vulnerable, reflecting their exposure to shifts in global markets.

External drivers of global commodity prices in fossil-intensive sectors remain highly unpredictable. Shifts in global commodity demand, evolving buyer requirements, cost competitiveness, and fragmented investor standards may affect the financial health of Indonesian firms reliant on these commodities.

Our stress-tested results indicate that borrowers in Indonesia's coal, oil & gas, and electricity sectors are particularly sensitive to these external factors. While our model does not isolate the influence of domestic policies and regulations, some observed sectoral patterns seem to reflect how such policy arrangements may shape firms'

ability to absorb external shocks. These patterns underscore the central role these commodities play in Indonesia's economic structure and highlight the ongoing role of domestic policy frameworks in shaping sectoral resilience, particularly policies aimed at maintaining affordability for end users.

Fossil fuels are expected to remain a substantial component of the country's energy mix through the 2040s to ensure energy reliability. Therefore, a long-term plan to transition away from fossil fuels is critical to avoid stagnation (or worse, outright reversal) in the deployment of cleaner alternatives. A long-term plan with credible milestones is essential to ensure an orderly transition with minimal risk of future disruption.

A more concise and transparent long-term framework on the utilisation and eventual retirement of coal, the role of natural gas as a reliable alternative, and the potential scale of renewable energy generation would provide a clearer picture of the intended transition pathway. This clarity would help mitigate risks arising from volatile commodity prices, reduce default risk, and support a more orderly reallocation of capital by enabling more informed investment decisions in a more predictable environment.

As discussed, the default risk in these sectors is affected heavily by global commodity price movements. While domestic pricing and market arrangements (e.g., regulated electricity tariffs, coal price caps, and domestic market obligations) help manage short-term affordability concerns, these policies dampen the economic incentives for electricity producers and industrial users to move away from fossil fuels. As a result, progress on the transition away from fossil fuels and in undertaking the necessary structural adjustments has been slow.

One potential approach for banks to mitigate transition risk is to adopt adaptive financing structures that incorporate loss-mitigating stipulations. These may include sustainability-linked covenants or milestone-based disbursements, while still supporting firms' transition efforts. This would enable a wider range of companies to access financing for capital expenditure or refinancing needs, particularly those undertaking credible transition investments.

Strengthening data availability is also essential to reduce transition risk. It is important to ensure that company-level emission data is available and consistent, asset-level disclosures have taken place, and the implementation of sectoral benchmarks are present. This would aid the banks' ability to incorporate transition risk into pricing, provisioning, and capital planning.

In summary, a clearer long-term policy trajectory, improved sectoral guidance, better data availability, and more adaptive financing structures would enable banks to more effectively assess and manage transition risk and reduce systemic vulnerability to external shocks.

Physical risks can affect borrowers through multiple financial channels. Repeated operational disruptions, higher maintenance and repair costs, lower asset utilisation, and increased insurance premia can erode operating performance. These pressures may weaken EBITDA and interest-coverage ratios, reducing borrowers' resilience to financial stress. Physical damage to assets used as collateral can also depress recovery values. Together, these effects can increase default probabilities and reduce recovery rates, particularly for asset-intensive firms, leading to a deterioration in credit quality.

Our physical risk analysis of Indonesia's banking sector shows that flood-related physical impacts on borrowers' assets intensify across all sectors in the economy as the century progresses. Even sectors traditionally viewed as less exposed, such as service industries, are projected to experience meaningful increases in asset loss by 2090.

At the portfolio level, exposure-weighted flood impacts are projected to rise across all banks, averaging around 0.4 percent per annum by mid-century and increasing further under the most adverse climate scenario. These substantial long-run patterns underscore the importance of sustained national and international efforts on climate mitigation, alongside adaptation measures to limit physical impacts already embedded in the system. Without effective policy action, physical risks are likely to intensify, reaching up to 61 percent higher for the most adverse climate scenario relative to the baseline, significantly amplifying the burden on borrowers and increasing risks to banks and the broader financial system.

While flood risk affects all borrowers, the composition of banks' portfolios plays an important role in shaping their overall vulnerability. Sector concentration remains a key transmission channel. Activities such as mining and electricity generation, given their location patterns and reliance on fixed infrastructure, are more exposed to flood hazards than others. Understanding how sectoral allocations amplify physical impacts is therefore essential for assessing portfolio and systemic resilience.

At the same time, our analysis shows that effective physical-risk management must extend beyond sector-level diversification. Even among borrowers within the same sector, hazard exposure can vary widely due to differences in site elevation, proximity to water bodies, geographic clustering, and local adaptation measures. The results of our volatility and tail analyses indicate that financing a small number of large, flood-prone projects can generate disproportionate portfolio-level effects, with these highly

vulnerable borrowers contributing significantly to overall portfolio stress. Strengthening physical-risk frameworks will therefore require attention to both sector-level patterns and borrower-specific characteristics, including greater consideration of geographic dispersion and asset vulnerability, alongside prudent capital buffers.

These challenges are long-term in nature. Across all climate scenarios we considered, physical impacts are projected to rise more sharply after 2050, underscoring the need for forward-looking risk planning. Strategic portfolio reviews, enhanced data on borrowers' asset locations and vulnerabilities, and scenario-based capital assessments will become increasingly critical as climate trajectories diverge.

Finally, measures to manage physical risk interact closely with transition-risk considerations. Reducing exposure to sectors or regions with elevated physical hazard exposure may inadvertently constrain the financing available to firms undertaking critical decarbonisation efforts. To avoid slowing the transition, public institutions, including government agencies and development finance institutions, may need to expand support through guarantees, blended-finance structures, and other risk-sharing instruments. Such interventions can help align physical risk management with broader objectives for an orderly and inclusive transition.

Key Takeaways:

- **Transition risk is persistent and global in nature.** A gradual domestic policy path limits near-term transition shocks, but global transition dynamics still transmit risk to fossil-intensive sectors and their lenders. Stress tests indicate a 35 percent potential increase in expected loss intensity due to carbon exposures, underscoring the need for ongoing monitoring of external drivers.

- **Policy clarity is essential to mitigate externally driven transition risk.** Clear long-term guidance on credible energy transition pathways can reduce uncertainty, improve risk pricing and capital allocation across sectors, and limit spillovers from global transition dynamics to the banking sector.

- **Physical climate risks are material, intensifying, and increasingly systemic.** Under the baseline climate scenario, large domestic commercial banks face projected flooding-related asset losses of around 0.4 percent annually by 2060, with risk accumulation intensifying thereafter. Projected losses are broad-based across sectors, including those conventionally viewed as less exposed. Under adverse climate scenarios, projected asset losses increase by more than 60 percent relative to the baseline.

- **Physical risk is magnified by concentrated borrower exposure.** Sharp variations in vulnerabilities across borrowers and asset locations mean that a small number of highly exposed assets can drive disproportionate portfolio losses. Sectoral, geographic, and project-level concentration further amplify tail risks under stress-testing scenarios.

- **Banks need more integrated frameworks and tools to manage climate risks.** The estimated climate-risk amplification is broadly in line with central bank climate stress-testing exercises elsewhere despite differences in modelling approaches, and by and large is higher than estimates for advanced economies, reflecting differences in policy context, economic development, and stage of transition. Robust financing structures and consistent, granular, asset-level data are essential for accurate risk pricing, provisioning, and capital planning, supporting effective and credible transition investments.

Appendix

VI. Appendix

1. NDC Expanded Analysis

Indonesia's Nationally Determined Contribution (NDC) outlines the country's long-term emissions trajectory and anchors climate ambition within national development priorities.

While the Second NDC (2025) introduces notable methodological updates, shift from BAU-based targets to the inventory-based absolute baseline (See Table A 1), the underlying policy direction remains consistent.

Table A 1 Indonesia NDC Evolution

NDC version - Year	Target Framing	2030 Emission Goals	Key Assumptions
Original NDC - 2016	% reduction from BAU 2030	29 % (unconditional) 41 % (cond.)	Focused on forestry and land use (≈97 % of target).
			Used projected BAU baseline from 2000–2030.
			Limited treatment of industrial process and product use (IPPU).
Updated NDC - 2021	No change	No change	Reaffirmed net-zero 2050/2060 vision through LTS-LCCR 2050 submission.
Enhanced NDC (ENDC) -2022	No change	31.89 % (unconditional) 43.20 % (conditional)	Raised ambition slightly vs 2016.
			Linked to Long-Term Strategy (LTS-LCCR 2050).
Second NDC (SNDC) - 2025	2019 inventory baseline (≈1,845 Mt CO_2e) vs 2030 absolute emission with three scenarios (CPOS, LCCP_L, LCCP_H)	≈1,780 Mt CO_2e (CPOS) (unconditional) ≈1,346 Mt CO_2e (LCCP_L) (conditional) ≈1,491 Mt CO_2e (LCCP_H) (conditional ++)	Baseline shifted from projected BAU to observed 2019 inventory data.
			Extended GHG scope to include HFCs and upstream oil & gas.
			Added dual economic growth scenarios. 6% economic growth for CPOS and LCCP_L and 7% for LCCP_H

Adapted from: Indonesia FNDC, Updated NDC, Enhanced NDC, and SNDC

Emission Profile and Sectoral Dynamics

Across all three emissions scenarios in the Second NDC (SNDC), both conditional and unconditional, emissions are projected to peak around the mid-2030 (Figure A 1). Energy-related emissions continue rising into the early 2030s (see Figure A 2) a trend consistent with historical inventories. The 2019 BUR recorded the energy sector produce 34.49 percent of total emissions, and the 2022 BTR shows this increasing to 69.01 percent following a sharp decline in land-use emissions. This reflects Indonesia's structural reliance on coal for electricity generation, oil for transport and industrial demand, and the growing use of natural gas as a transitional fuel to support system reliability. These dynamics are closely tied to policy priorities that balance economic growth, affordability, and energy security.

Figure A 1 Indonesia Net Zero Strategy According to SNDC
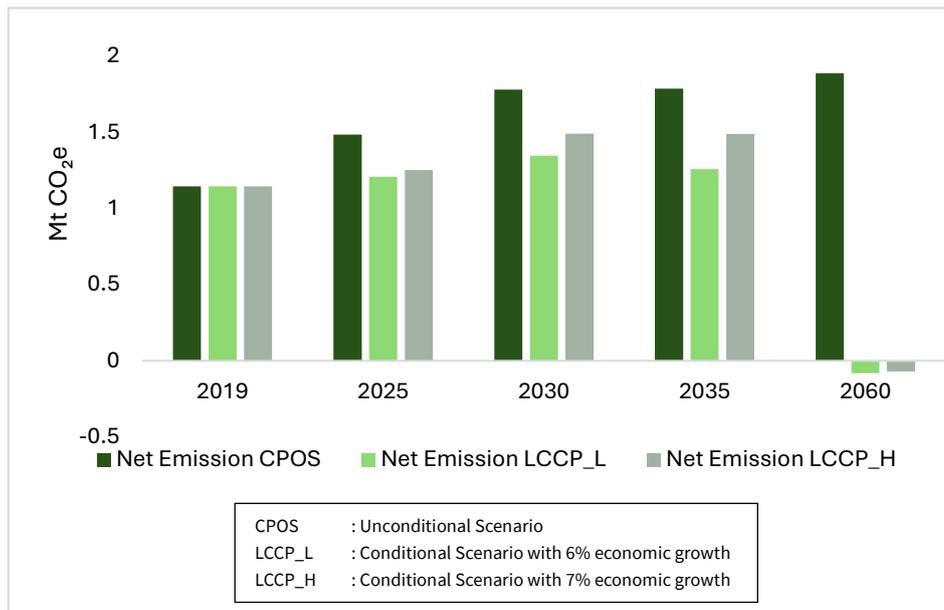
Adapted from Indonesia's SNDC

Figure A 2 Indonesia Net Zero Strategy According to SNDC
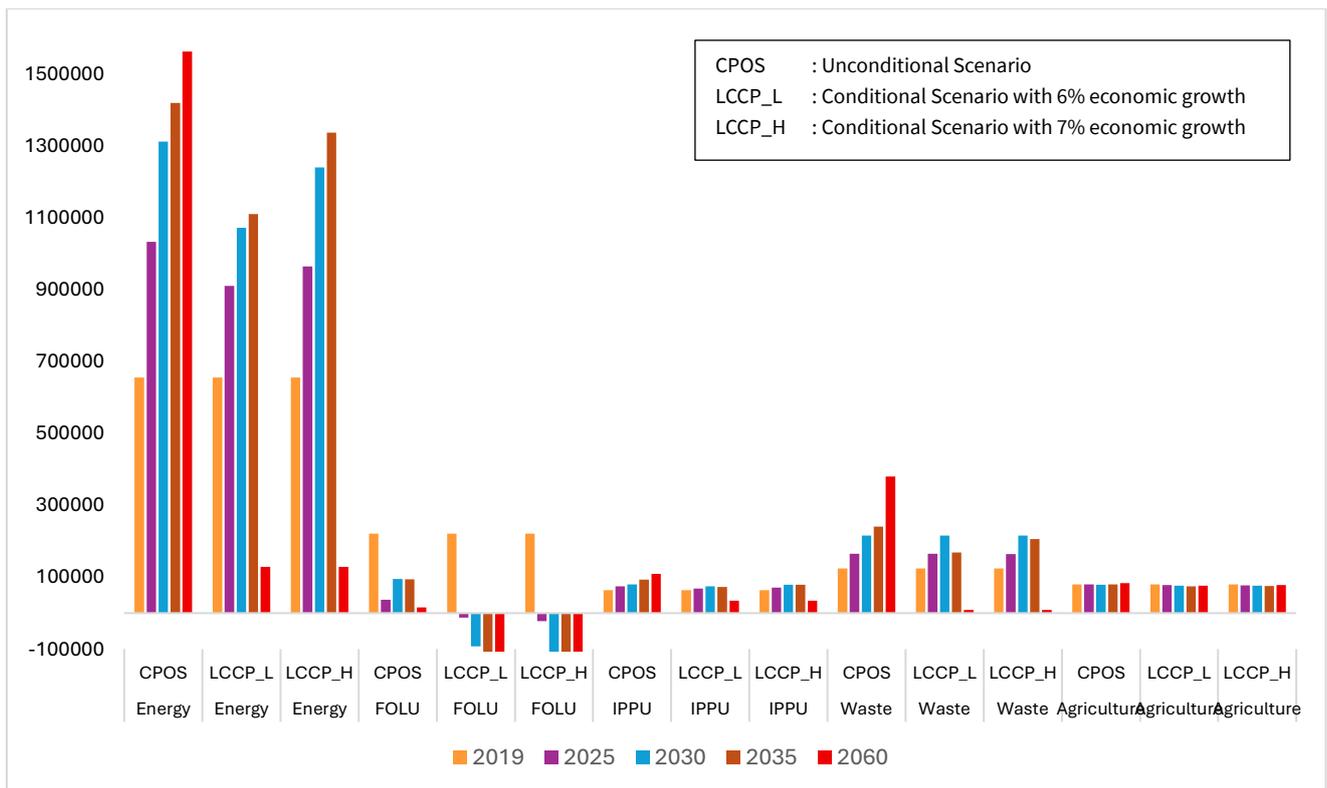
Adapted from Indonesia's SNDC

Implications for Transition-Risk Assessment

From a financial-risk perspective, the move toward absolute-emissions metrics improves transparency but does not materially shift near-term policy signals or transition-risk dynamics. The SNDC does not introduce sector-specific caps, binding interim reduction trajectories, compliance mechanism or enforceable limits on fossil-fuel expansion in the near term. Consequently, while the SNDC clarifies Indonesia's long-term pathway, it does not materially intensify near-term domestic policy risk. Transition-risk exposure for financial institutions therefore continues to be driven primarily by global technology trends, commodity-price dynamics, and shifts in investor sentiment rather than abrupt regulatory tightening.

2. RUPTL and RUKN Expanded Analysis

The backbone of Indonesia's energy sector is PT PLN (Perusahaan Listrik Negara), a state-owned company that monopolizes electricity generation, transmission, and distribution. Every decade, PLN in collaboration with the Ministry of Energy and Mineral Resources (ESDM), publishes the Electricity Supply Business Plan (RUPTL), which sets the country's roadmap for electricity development, including renewable energy deployment.

Capacity Expansion and Energy Mix

For the period 2025-2034, PLN plans to add 69.5GW of new installed capacity with 42.6GW (≈ 61 percent) coming from renewable sources, primarily solar, hydropower, and wind, with smaller shares from geothermal, bioenergy and nuclear. The plan also includes additional 10.3GW storage (See Figure A 3). This number is growing significantly from 2019-2028 plan which only cover roughly 29-31 percent of total additional target and 52 percent of additional target in 2021-2030 plan. If implemented, this expansion would raise renewable energy share in electricity generation from 12 percent in 2024 to 34.3 percent by 2034.[54]

Figure A 3 Energy Mix for RUPTL 2025-2034 Additional Capacity in GigaWatt

Total Additional Capacity 69.5 GW

Segment	Value
Nuclear	0.9
Bioenergy	
Geothermal	5.2
Wind	7.2
Water	11.7
Solar	17.1
Gas	10.3
Coal	6.3
Pumped Storage	4.3
Battery	6.0
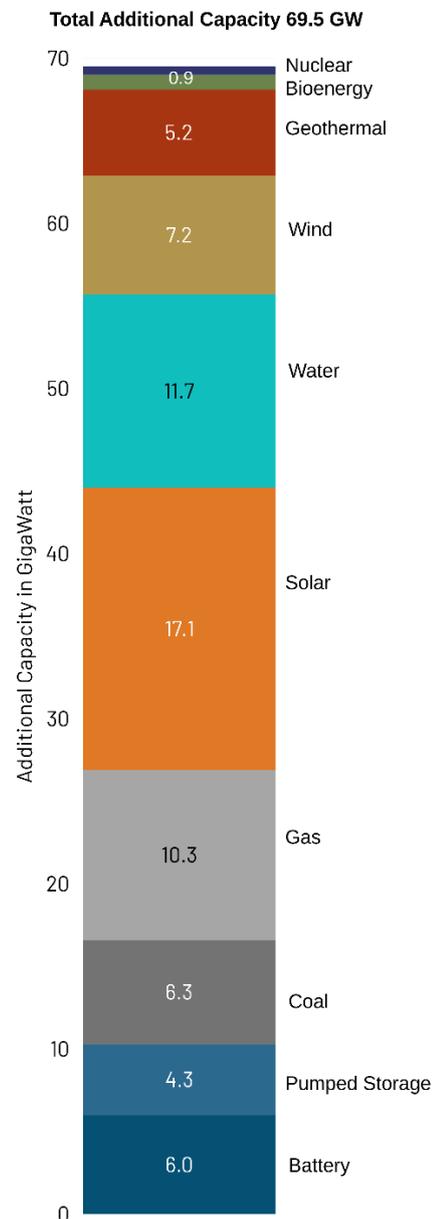
Adapted from: PLN RUPTL

Investment Requirements and Financing Architecture

The total investment envelope for 2025–2034 is enormous. Total capital expenditure, maintenance, and interest during construction (IDC, ≈10 percent) is estimated at USD 188 billion

(≈IDR 2,967 trillion). PLN financial capacity will only address only around 27 percent of that amount. The remainder is expected to come from Independent Power Producers (IPPs) through long-term Power Purchase Agreements (PPAs), effectively expanding the public–private partnership model in the power sector. While this model has proven workable for coal-based projects, its success in renewables will depend on tariff competitiveness (vis-à-vis coal and gas), contract transparency (i.e. non-costed risks, curtailment, or dispatch priority), and regulatory certainty. Variable generation, balancing costs, and grid-expansion requirements shift more system-level risk toward the off-taker. Without adjustments to PLN's offtake pricing and risk-sharing framework, private investors may still perceive renewable PPAs as less bankable. [55]

The Long-Term National Electricity Plan (RUKN 2025–2060)

The broader transformation pathway outlined in the RUKN provides the foundational context for interpreting the RUPTL 2025–2034, which functions as its first operational tranche. The RUKN projects total installed capacity to reach 443 GW by 2060, with 41.6 percent from variable renewables (VRE), complemented by stable renewables, fossil plants equipped with CCS, and 34 GW of storage to maintain system adequacy. Coal remains the dominant source of generation until around 2035 (See Figure A 4), reflecting the need to preserve baseload reliability during the early decades of transition. The RUPTL mirrors this long-term trajectory in both direction and pacing. In the near term, coal remains embedded as baseload to safeguard system reliability, while renewable expansion proceeds gradually in line with grid readiness, resource–demand alignment, and the availability of supporting infrastructure. Gas continues to play a crucial role in balancing variable renewable output, while more advanced technologies will only materialize after 2045.

Figure A 4 National Energy Policy Mix & Capacity Projection in Giga Watt
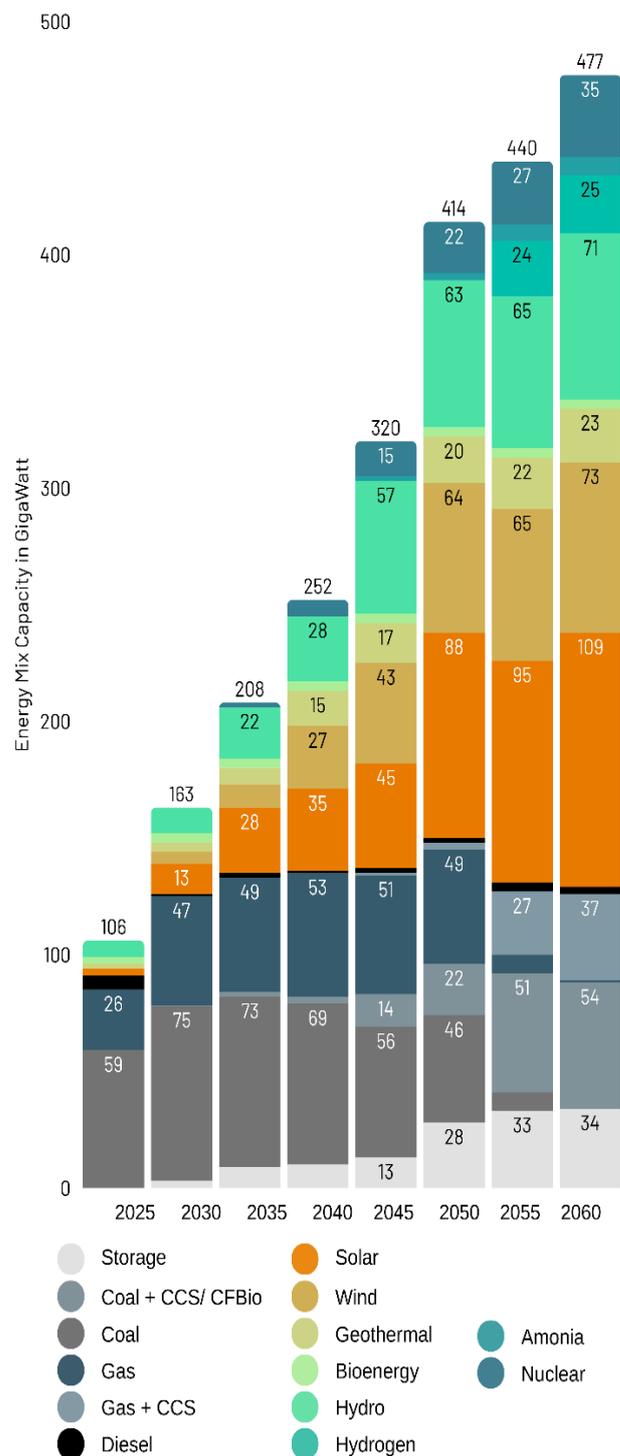
Adapted from Ministry of Energy and Resources RUKN

Implication for Risk Assessment and Investment Planning

RUPTL's aggressive renewable targets signal significant expansion opportunities. However, the feasibility of delivery hinges on grid bottlenecks (particularly in Java-Bali and outside systems), PLN's constrained balance sheet, bankability of renewable PPAs, and fair but affordable tariff. Viability will also require complementary fiscal support and strengthened procurement processes under evolving MEMR regulations.

3. JETP Expanded Analysis

Investment Plan Structure

The Just Energy Transition Partnership (JETP) has become Indonesia's flagship financing cooperation framework to accelerate a just and managed transition away from coal. It has mobilised USD 21.6 billion in combined public and private commitments to support Indonesia's energy transition.

JETP's investment plan (CIPP 2023) is structured around six focus areas that mirror Indonesia's electricity sector challenges:

a. Energy efficiency and electrification, (newly added to emphasize demand-side management),
b. Transmission and distribution (grid) upgrades,
c. Dispatchable renewable projects,
d. Variable renewable energy acceleration,
e. Coal plant repurposing, and
f. Renewable energy supply chain development.

As of 2025, around 494 projects have been screened and 89 prioritized, ranging from hydro and geothermal to solar, wind, and transmission infrastructure.

Financing Architecture

Figure A 5 JETP Funding Pledge (in biillion USD)
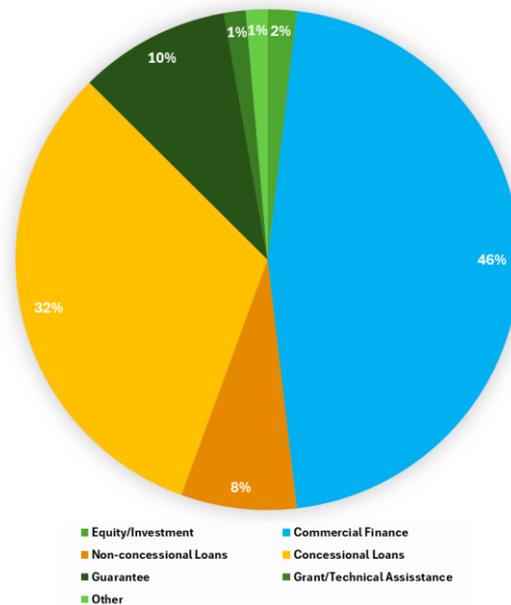
Adapted from JETP

As seen in Figure A 5, majority of it are on the debt instrument with some de-risking instrument like guarantee or equity and grant. Each instruments carries different implications. Concessional loans reduce financing cost but are capped in size; commercial loans introduce repayment pressure; while guarantees and equity can mobilize private capital but require robust regulatory frameworks. Grants, while small in volume, can support areas critical for pipeline maturation such as support project preparation and regulatory reform.

The predominance of debt means JETP strengthens leverage rather than providing fiscal relief. For entities like PLN, with regulated tariffs and legacy cost structures, additional borrowing does not directly ease affordability pressures unless coupled with tariff reforms, system-integration solutions, or rebalancing of coal-contract obligations.

Financing Pipeline

By September 2025, only USD 2.85 billion had reached approval across five programmes and four projects, largely directed toward geothermal expansion, renewable-energy preparation, transmission upgrades, and selective de-dieselisation initiatives. These approvals are mainly concessional and do not yet reflect the broader USD 20-billion headline commitment See Figure A 6.

Meanwhile, 22 programmes and projects are under review, amounting to an estimated USD 5.5–6.2 billion. These remain pipeline commitments without financial close, pending further design, regulatory alignment, and risk-mitigation arrangements.
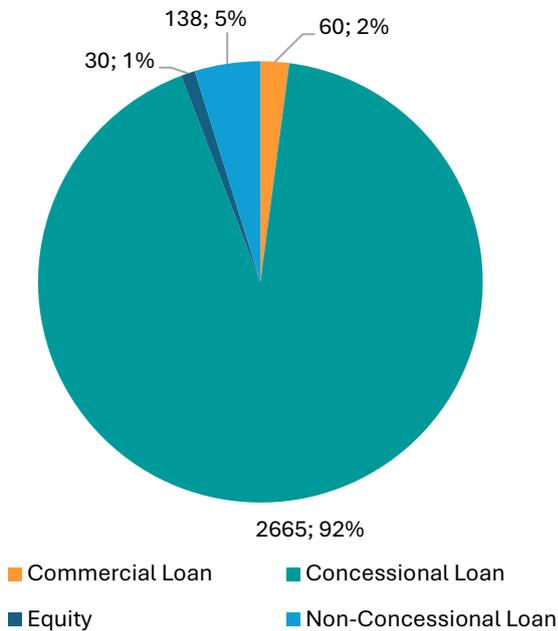
Figure A 6 Type and Amount of Financing Approved for JETP Program and Projects (Million USD)

Adapted from JETP

System-Level Implications

Some entities listed as beneficiaries include the Ministry of Finance, PLN, and independent power producers. However, PLN also serves as the sole off taker under Renewable PPAs as defined in MEMR Regulation No. 5 of 2025.[56] The challenge arises not from the off-taker structure itself but from inflexible take-or-pay contracts, tariff-setting constraints that limit cost recovery, system-integration costs for variable renewable energy, and the need for accelerated transmission.

In a system where cost recovery is tightly regulated, additional debt-financed renewable investments can strain PLN's balance sheet unless accompanied by reforms that could stabilise revenue recovery, enable flexible procurement, or targeted fiscal support. These contrasts suggest that any further assessment of financial implications would benefit from analytical approaches that take both spatial concentration and asset characteristics into account. While this study focuses on establishing the exposure landscape, the distributional patterns observed here provide a useful foundation for more detailed evaluation of how localized flooding could interact with firms' operational structures and, by extension, portfolio-level sensitivities.

4. Company-Level Transition Assessment Score

Table A 2 TRS Target Setting & Sectoral Alignment Results

Company	Sector	Target Setting & Sectoral Alignment			
		2021	2022	2023	2024
PT Bumi Resources Tbk	Mining - Coal	0.00%	0.00%	0.00%	0.00%
PT Adaro Energy Tbk	Mining - Coal	0.00%	0.00%	75.00%	50.00%
PT Bayan Resources Tbk	Mining - Coal	0.00%	0.00%	0.00%	0.00%
PT Indo Tambangray Megah Tbk	Mining - Coal	0.00%	0.00%	0.00%	75.00%
PT Bukit Asam Tbk	Mining – Coal	0.00%	50.00%	75.00%	75.00%
PT Vale Indonesia Tbk	Mining – Nickel	75.00%	75.00%	75.00%	75.00%
PT Aneka Tambang Tbk (ANTAM)	Mining – Nickel, Gold, Bauxite	50.00%	50.00%	50.00%	50.00%
PT TBS Energi Utama Tbk	Mining – Coal	50.00%	50.00%	50.00%	75.00%
PT United Tractors Tbk	Mining – Coal, Gold	0.00%	0.00%	75.00%	75.00%
Perusahaan Listrik Negara (PLN)	Electricity Generation	0.00%	50.00%	75.00%	75.00%
Medco Energi	Oil & Gas	50.00%	75.00%	75.00%	75.00%
Pertamina	Oil & Gas	0.00%	75.00%	75.00%	75.00%
PT Cirebon Electric Power	Utilities	0.00%	0.00%	0.00%	0.00%
PT Cikarang Listrindo Tbk	Utilities	0.00%	75.00%	75.00%	75.00%
PT PLN Nusantara Power	Utilities	0.00%	75.00%	75.00%	75.00%

Table A 3 TRS Emission Coverage & Reduction Strategy Results

Company	Sector	Emission Coverage & Reduction Strategy			
		2021	2021	2021	2021
PT Bumi Resources Tbk	Mining - Coal	50.00%	50.00%	50.00%	50.00%
PT Adaro Energy Tbk	Mining - Coal	50.00%	50.00%	50.00%	66.67%
PT Bayan Resources Tbk	Mining - Coal	50.00%	50.00%	33.33%	33.33%
PT Indo Tambangray Megah Tbk	Mining - Coal	83.33%	83.33%	83.33%	83.33%
PT Bukit Asam Tbk	Mining – Coal	83.33%	83.33%	83.33%	83.33%
PT Vale Indonesia Tbk	Mining – Nickel	50.00%	50.00%	50.00%	50.00%
PT Aneka Tambang Tbk (ANTAM)	Mining – Nickel, Gold, Bauxite	50.00%	50.00%	83.33%	83.33%
PT TBS Energi Utama Tbk	Mining – Coal	50.00%	50.00%	50.00%	50.00%
PT United Tractors Tbk	Mining – Coal, Gold	50.00%	50.00%	50.00%	66.67%
Perusahaan Listrik Negara (PLN)	Electricity Generation	66.67%	83.33%	100.00%	100.00%
Medco Energi	Oil & Gas	50.00%	50.00%	50.00%	83.33%
Pertamina	Oil & Gas	83.33%	83.33%	83.33%	83.33%
PT Cirebon Electric Power	Utilities	16.67%	16.67%	16.67%	16.67%
PT Cikarang Listrindo Tbk	Utilities	83.33%	83.33%	100.00%	83.33%
PT PLN Nusantara Power	Utilities	50.00%	83.33%	100.00%	83.33%

Table A 4 TRS Governance and Accountability Results

Company	Sector	Governance and Accountability			
		2021	2021	2021	2021
PT Bumi Resources Tbk	Mining - Coal	0.00%	0.00%	0.00%	50.00%
PT Adaro Energy Tbk	Mining - Coal	0.00%	50.00%	50.00%	50.00%
PT Bayan Resources Tbk	Mining - Coal	0.00%	50.00%	0.00%	0.00%
PT Indo Tambangray Megah Tbk	Mining - Coal	50.00%	50.00%	50.00%	50.00%
PT Bukit Asam Tbk	Mining – Coal	50.00%	50.00%	0.00%	50.00%
PT Vale Indonesia Tbk	Mining – Nickel	0.00%	0.00%	0.00%	50.00%
PT Aneka Tambang Tbk (ANTAM)	Mining – Nickel, Gold, Bauxite	0.00%	0.00%	50.00%	50.00%
PT TBS Energi Utama Tbk	Mining – Coal	0.00%	50.00%	50.00%	50.00%
PT United Tractors Tbk	Mining – Coal, Gold	0.00%	0.00%	50.00%	50.00%
Perusahaan Listrik Negara (PLN)	Electricity Generation	0.00%	0.00%	50.00%	50.00%
Medco Energi	Oil & Gas	100.00%	100.00%	100.00%	100.00%
Pertamina	Oil & Gas	100.00%	100.00%	100.00%	50.00%
PT Cirebon Electric Power	Utilities	0.00%	0.00%	0.00%	0.00%
PT Cikarang Listrindo Tbk	Utilities	0.00%	0.00%	0.00%	50.00%
PT PLN Nusantara Power	Utilities	0.00%	0.00%	0.00%	50.00%

Table A 5 TRS Financial Integration Results

Company	Sector	Financial Integration			
		2021	2021	2021	2021
PT Bumi Resources Tbk	Mining - Coal	0.00%	0.00%	0.00%	0.00%
PT Adaro Energy Tbk	Mining - Coal	0.00%	100.00%	0.00%	0.00%
PT Bayan Resources Tbk	Mining - Coal	100.00%	100.00%	100.00%	100.00%
PT Indo Tambangray Megah Tbk	Mining - Coal	0.00%	0.00%	0.00%	0.00%
PT Bukit Asam Tbk	Mining – Coal	0.00%	0.00%	0.00%	0.00%
PT Vale Indonesia Tbk	Mining – Nickel	0.00%	0.00%	0.00%	100.00%
PT Aneka Tambang Tbk (ANTAM)	Mining – Nickel, Gold, Bauxite	0.00%	0.00%	0.00%	100.00%
PT TBS Energi Utama Tbk	Mining – Coal	0.00%	0.00%	0.00%	0.00%
PT United Tractors Tbk	Mining – Coal, Gold	0.00%	0.00%	0.00%	0.00%
Perusahaan Listrik Negara (PLN)	Electricity Generation	0.00%	0.00%	0.00%	0.00%
Medco Energi	Oil & Gas	0.00%	0.00%	0.00%	0.00%
Pertamina	Oil & Gas	0.00%	0.00%	0.00%	0.00%
PT Cirebon Electric Power	Utilities	0.00%	0.00%	0.00%	0.00%
PT Cikarang Listrindo Tbk	Utilities	100.00%	100.00%	100.00%	100.00%
PT PLN Nusantara Power	Utilities	0.00%	0.00%	0.00%	0.00%

Table A 6 TRS Disclosures & Transparency Results

Company	Sector	Disclosures & Transparency			
		2021	2021	2021	2021
PT Bumi Resources Tbk	Mining - Coal	50.00%	50.00%	50.00%	50.00%
PT Adaro Energy Tbk	Mining - Coal	50.00%	100.00%	100.00%	50.00%
PT Bayan Resources Tbk	Mining - Coal	0.00%	50.00%	50.00%	50.00%
PT Indo Tambangray Megah Tbk	Mining - Coal	50.00%	50.00%	50.00%	50.00%
PT Bukit Asam Tbk	Mining – Coal	100.00%	100.00%	100.00%	100.00%
PT Vale Indonesia Tbk	Mining – Nickel	100.00%	100.00%	50.00%	50.00%
PT Aneka Tambang Tbk (ANTAM)	Mining – Nickel, Gold, Bauxite	50.00%	100.00%	150.00%	100.00%
PT TBS Energi Utama Tbk	Mining – Coal	50.00%	100.00%	100.00%	150.00%
PT United Tractors Tbk	Mining – Coal, Gold	50.00%	50.00%	100.00%	100.00%
Perusahaan Listrik Negara (PLN)	Electricity Generation	50.00%	50.00%	50.00%	100.00%
Medco Energi	Oil & Gas	100.00%	150.00%	150.00%	150.00%
Pertamina	Oil & Gas	100.00%	150.00%	150.00%	100.00%
PT Cirebon Electric Power	Utilities	50.00%	50.00%	50.00%	50.00%
PT Cikarang Listrindo Tbk	Utilities	100.00%	100.00%	100.00%	100.00%
PT PLN Nusantara Power	Utilities	50.00%	50.00%	50.00%	50.00%

Table A 7 TRS Climate Risk Scenario Results

Company	Sector	Climate Risk Scenario			
		2021	2021	2021	2021
PT Bumi Resources Tbk	Mining - Coal	50.00%	50.00%	50.00%	50.00%
PT Adaro Energy Tbk	Mining - Coal	0.00%	50.00%	50.00%	0.00%
PT Bayan Resources Tbk	Mining - Coal	50.00%	50.00%	50.00%	0.00%
PT Indo Tambangray Megah Tbk	Mining - Coal	50.00%	50.00%	50.00%	0.00%
PT Bukit Asam Tbk	Mining – Coal	50.00%	50.00%	50.00%	0.00%
PT Vale Indonesia Tbk	Mining – Nickel	0.00%	50.00%	50.00%	0.00%
PT Aneka Tambang Tbk (ANTAM)	Mining – Nickel, Gold, Bauxite	0.00%	50.00%	50.00%	0.00%
PT TBS Energi Utama Tbk	Mining – Coal	0.00%	50.00%	50.00%	100.00%
PT United Tractors Tbk	Mining – Coal, Gold	0.00%	0.00%	50.00%	100.00%
Perusahaan Listrik Negara (PLN)	Electricity Generation	0.00%	50.00%	50.00%	100.00%
Medco Energi	Oil & Gas	50.00%	50.00%	50.00%	100.00%
Pertamina	Oil & Gas	50.00%	50.00%	50.00%	100.00%
PT Cirebon Electric Power	Utilities	0.00%	0.00%	0.00%	0.00%
PT Cikarang Listrindo Tbk	Utilities	50.00%	50.00%	50.00%	100.00%
PT PLN Nusantara Power	Utilities	0.00%	0.00%	0.00%	0.00%

Table A 8 Transition Pathway Initative Management Quality Evaluation

Level		Question	PLN	TBS	Adaro	Pertamina	Medco
0	1	Does the company acknowledge climate change as a significant issue for the business?	Y	Y	Y	Y	Y
1	2	Does the company recognise climate change as a relevant risk and/or opportunity for the business?	Y	Y	Y	Y	Y
	3	Does the company have a policy (or equivalent) commitment to action on climate change?	Y	Y	Y	Y	Y
2	4	Has the company set greenhouse gas emission reduction targets?	Y	Y	Y	Y	Y
	5	Has the company published information on its operational (Scope 1 and 2) greenhouse gas emissions?	Y	Y	Y	Y	Y
3	6	Has the company nominated a board member or board committee with explicit responsibility for oversight of the climate change policy?	Y	Y	Y	Y	Y
	7	Has the company set quantitative targets for reducing its greenhouse gas emissions?	Y	N	Y	Y	Y
	8	Does the company report on Scope 3 emissions?	Y	N	N	Y	Y
	9	Has the company had its operational (Scope 1 and/or 2) greenhouse gas emissions data verified?	N	Y	Y	Y	Y
	10	Does the company support domestic and international efforts to mitigate climate change?	Y	Y	Y	Y	Y
	11	Does the company have a process to manage climate-related risks?	N	Y	Y	Y	Y
	12	Does the company disclose materially important Scope 3 emissions?	Y	N	N	Y	Y
4	13	Has the company set long-term quantitative targets for reducing its greenhouse gas emissions?	N	N	Y	N	Y
	14	Does the company's remuneration for senior executives incorporate climate change performance?	N	N	N	N	Y
	15	Does the company incorporate climate change risks and opportunities in their strategy?	Y	Y	Y	Y	Y
	16	Does the company undertake climate scenario planning?	Y	Y	N	Y	Y
	17	Does the company disclose an internal price of carbon?	N	N	N	N	N

Table A 8 Transition Pathway Initative Management Quality Evaluation

Level		Question	PLN	TBS	Adaro	Pertamina	Medco
	18	Does the company disclose the actions planned to meet its emissions reduction targets?	Y	N	Y	Y	Y
5	19	Does the company quantify the key elements of its emissions reduction strategy and the proportional impact of each action in achieving its targets?	N	N	N	N	N
	20	Does the company's transition plan clarify the role that will be played by offsets and/or negative emissions technologies?	N	N	Y	Y	N
	21	Does the company commit to phasing out capital expenditure in carbon intensive assets or products?	N	Y	N	N	N
	22	Does the company align future capital expenditures with its long-term decarbonisation goals and disclose how the alignment is determined?	N	N	N	N	N
	23	Does the company ensure consistency between its climate change policy and the positions taken by trade associations of which it is a member?	N	N	Y	Y	N

Complementarity between TPI Management Quality and Transition Assessment Framework

Alongside the results illustrated in Table 2 and Table A 8, it must be noted that the TPI Management Quality framework and the TRS has some differences that lead different results in certain segments.

One glaring difference is the consideration is the assessment of the financial integration of the transition plan. With the TPI framework, it tends to go into more detail and enquires details such as the Internal Price of Carbon Price, this is as opposed to the transition framework that generally enquires about the capital expenditure a company might have set aside for any low carbon practices it might implement.

On the other hand, the TRS investigates what sectoral pathways there might be whereas TPI tends to go for a general approach for all companies. TPI also don't seem to cover specifically whether widely used and accepted Validation and Verification bodies are used but rather just enquire if the data reported has been verified.

Overall TPI appears to identify broad target goals in general and does not go into the specifics on whether these goals have an assigned end date. This is opposed to the TRS where a specific net zero target year is required to be set.

The TRS could be considered more user friendly and practical. The indicators of the framework are clearly defined and leave minimal room for subjectivity as opposed to the TPI management quality framework. This clarity would enable organizations, especially those in the early stage of implementing their transition plans to apply the framework more effectively.

## Implications for Transition-Risk Assessment

The results indicate that while there is some year-on-year improvement, progress is uneven across sectors and remains largely confined to improvements in disclosures and target-setting rather than substantive further operational enhancement. Coal and mineral-mining companies show only marginal improvements and fail to show any consistent movement towards credible transition plans. In contrast, Oil & Gas and Utility companies exhibit more systematic progress, though their actions may still fall short of their relatively comprehensive transition plans.

For banks, these asymmetries matter. Even in the absence of strong domestic policy tightening, firms that are less likely to adopt a meaningful transition will be more exposed to external pressures associated with global commodity-price volatility, shifting buyer requirements, sustainability-linked financing costs, and long-term competitiveness risks.

5. Flood Exposure in Indonesia Based on IRBI Dataset

Figure A 7 Spatial Mapping of Corporate Assets Against IRBI Flood-Risk Levels
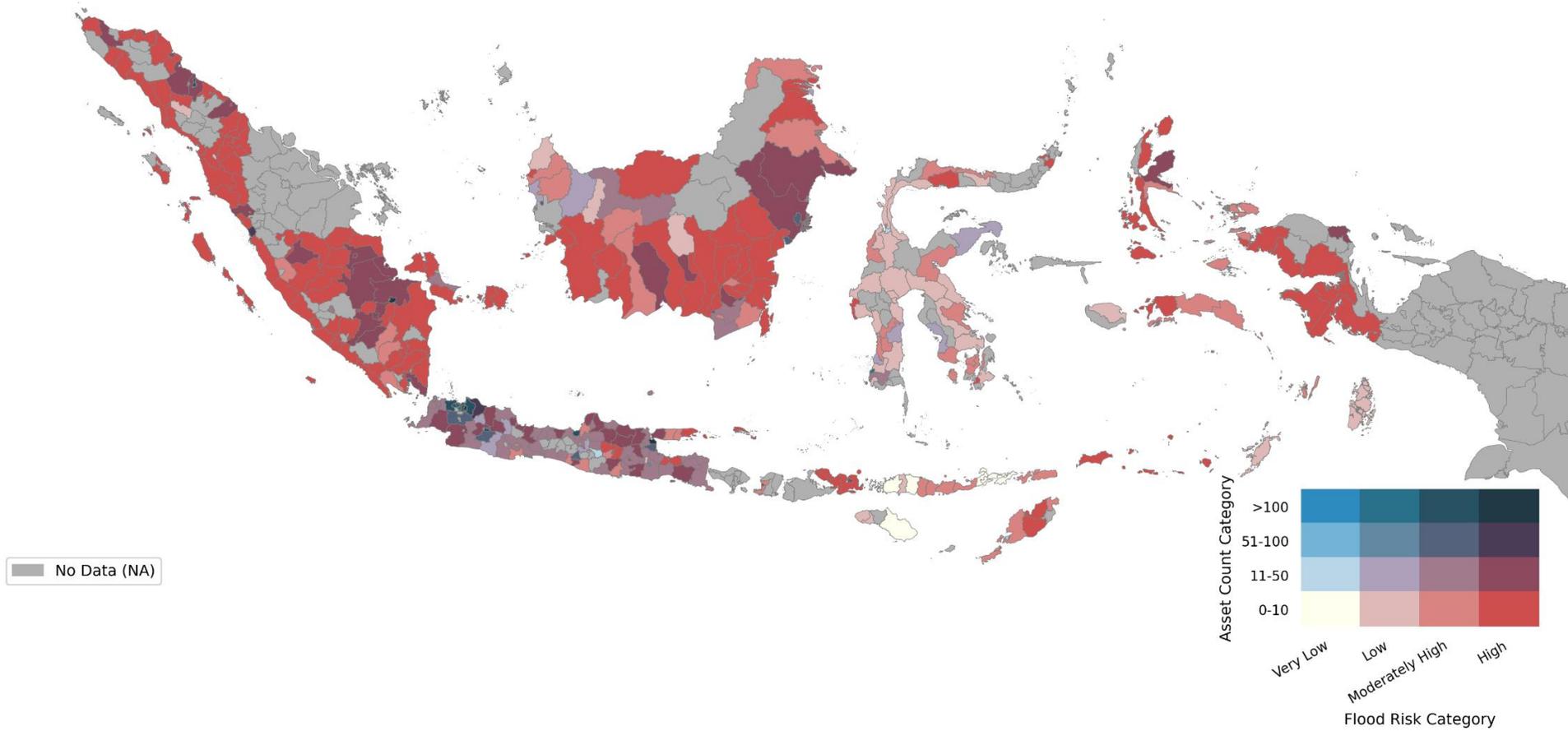
The map on Figure A 7 visualises the municipal flood-risk landscape across Indonesia using IRBI 2024 data. Scores range from 2.47 to 36, with the official BNPB "High" threshold starting at 11.94. To preserve interpretive clarity, the study divides the continuous IRBI flood scores into four intervals (Very Low < 5, Low 5–11.9, Moderate 12–19, High > 19). This gradation allows differences within the "High" band to remain visible because a city with a score of 12 (e.g., Bekasi) and one with 36 (e.g., Palembang) both fall in the same national class but represent very different hazard intensities and physical contexts.

The second layer of the map represents the spatial density of 9,559 geocoded corporate assets from Trucost. These assets cluster heavily in Java's industrial corridor (Jakarta-Bekasi-Karawang, Surabaya, Semarang) and a few provincial hubs such as Medan and Palembang. While more than half of Indonesian municipalities have <10 mapped assets, only 16 municipalities contain >100 facilities, showing that financial exposure is highly concentrated in a few economic centres.

The bivariate map overlays both IRBI scores with asset counts, revealing where physical hazard and financial exposure intersect most strongly. Municipalities shaded in darker tones indicate zones where moderate-to-high flood risk coincides with dense corporate activity for instance, Jakarta, Bekasi, and Surabaya. Conversely, areas like Palembang, exhibit extreme flood risk with 36 score but fer facilities, posing localized risk rather than systemic threats. This contrast shows that financial materiality is not linear with hazard intensity. A moderately risky municipality with thousands of assets can generate a larger aggregate loss potential than a high-risk but sparsely industrialised area.

These patterns also highlight the importance of examining physical risk at a more granular level of individual assets locations rather than relying solely on municipal classifications. Differences in hazard intensity and asset concentration create distinct risk profiles that aggregate maps cannot fully capture. In several municipalities, moderate flood scores coincide with dense clusters of economically important facilities, whereas some extreme-risk municipalities host only a small number of assets.

These contrasts suggest that any further assessment of financial implications would benefit from analytical approaches that take both spatial concentration and asset characteristics into account. While this study focuses on establishing the exposure landscape, the distributional patterns observed here provide a useful foundation for more detailed evaluation of how localized flooding could interact with firms' operational structures and, by extension, portfolio-level sensitivities.

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