

Lending Against the Tide: Coastal Credit Mismatch, Subsidence-Adjusted Bank Risk, and the Climate- Vulnerability Loan Premium in Pantura Central Java

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Abstract

The northern coast of Central Java, where land subsides between 2 and 20 centimetres per year and where bank credit reached IDR 423.5 trillion by mid-2025, provides a unique empirical laboratory for examining how the banking system prices and allocates credit in the presence of climate physical risk. We construct three diagnostic measures: the Coastal Credit Mismatch Index (CCMI) that captures sectoral under-allocation of credit to coastal-anchor sectors; the Subsidence-Adjusted Non-Performing Loan ratio (SANPL) that augments observed NPL with a physical-fragility loading; and the Climate-Vulnerability Loan Premium (CVLP) that quantifies the additional interest-rate compensation lenders would require under risk-neutral pricing. Using an unbalanced panel of 13 Pantura kabupaten over 2016 to 2021, we find that subsidence raises SANPL by approximately 4.6 basis points per centimetre-year (t-statistic equal to 3.3), with the effect compounding to approximately 55 basis points in Demak over the 6-year sample. The estimated CVLP for the highest-subsidence kabupaten reaches 135 to 270 basis points but is largely absent from the observed sectoral lending rate structure. The findings have direct implications for the asset-liability management of Indonesian regional banks, for OJK macroprudential reporting requirements, and for the design of the kafalah subsidy that underwrites KUR lending in subsidence-affected coastal areas.

Keywords: climate physical risk, bank credit allocation, land subsidence, non-performing loans, coastal Indonesia, KUR, macroprudential policy

1. Introduction

On 4 May 2026 the Coordinating Minister for Infrastructure and Regional Development presented a satellite-altimetry visualisation showing that the Demak coastline subsides at approximately 20 centimetres per year, among the most rapid land-subsidence rates documented globally. The visualisation was widely reported in Indonesian financial press and triggered renewed policy discussion regarding the implications of coastal land subsidence for the regional banking system that finances coastal economic activity. The northern coast of Central Java (Pantura) host 13 coastal kabupaten with approximately 18 million residents, substantial fishing and aquaculture sectors, and a banking system that channeled IDR 423.5 trillion of credit by mid-2025 with a loan-to-deposit ratio of 91.1 percent and a non-performing loan ratio of 2.94 percent. The intersection of accelerating physical risk and substantial credit exposure provides the empirical setting for our analysis.

We make three contributions. First, we construct the Coastal Credit Mismatch Index (CCMI)

as a kabupaten-level diagnostic of credit allocation relative to the underlying production structure. The CCMI is defined as the sum across coastal-anchor sectors (fishing, aquaculture, transport, processing) of the ratio of sectoral credit to sectoral GDP, normalised by the same ratio across all sectors. A CCMI below 1.0 indicates under-allocation to coastal sectors. Second, we develop the Subsidence-Adjusted Non-Performing Loan ratio (SANPL) that augments the observed kabupaten NPL with a physical-fragility loading proportional to the subsidence rate. The SANPL captures the credit-risk dimension that the observed NPL fails to internalise. Third, we quantify the Climate-Vulnerability Loan Premium (CVLP) as the cross-sectional differential lending rate that risk-neutral lenders would charge to coastal versus non-coastal borrowers given the observed subsidence-NPL relationship.

The empirical core uses an unbalanced panel of 13 kabupaten over 2016 to 2021 with 78 kabupaten-year observations, drawing on Bank Indonesia Perwakilan Jateng sectoral credit panels, BPS Jateng kabupaten-level GDP data, and subsidence rate estimates from Patel, Tay, Hassan, and Carey (2024) Nature Sustainability InSAR processing combined with Geological Agency 12-marker network data. The estimation framework uses kabupaten and year fixed effects with standard errors clustered at the kabupaten level.

Three findings deserve preview. First, the panel regression of changes in SANPL on the interaction of subsidence rate and time, with kabupaten and year fixed effects, yields a coefficient of approximately 4.6 basis points per centimetre-year (t-statistic equal to 3.3, p-value below 0.01). Over the 6-year window, this implies approximately 55 basis points of additional NPL accumulation in Demak (subsidence 20 cm/year) relative to a baseline kabupaten with negligible subsidence. Second, the CCMI declines from a 2016 mean of 0.43 to a 2021 mean of 0.31, indicating progressive under-allocation of credit to coastal-anchor sectors as physical risk salience increases. The decline is steepest in the highest-subsidence kabupaten, consistent with lender risk avoidance. Third, the estimated CVLP for the highest-subsidence kabupaten reaches 135 to 270 basis points but is essentially absent from the observed sectoral lending rate structure, indicating that the explicit interest-rate channel is not being used to price the documented credit-risk exposure.

The findings have direct implications for the asset-liability management of Indonesian regional banks, for OJK macroprudential reporting requirements, and for the design of the kafalah subsidy that underwrites KUR (Kredit Usaha Rakyat) lending in subsidence-affected coastal areas. The remainder of the paper proceeds as follows. Section 2 reviews the related literature. Section 3 describes the institutional setting and the three identification events. Section 4 specifies the data and empirical framework. Section 5 presents the principal results. Section 6 concludes with policy implications.

2. Literature Review

Our paper sits at the intersection of three literatures. The climate physical-risk and banking literature has expanded substantially over the past five years. Bolton and Kacperczyk (2023) document the global pricing of carbon-transition risk in equity markets, while Acharya, Berner, Engle, Jung, Stroebe, Zeng, and Zhao (2024) review the climate stress-testing methodology

applied to bank balance sheets across jurisdictions. Goldsmith-Pinkham, Gustafson, Lewis, and Schwert (2023) document the sea-level-rise exposure premium in US municipal bond yields, providing the closest international analogue to the channel we examine in Indonesian coastal banking. Ivanov, Macchiavelli, and Santos (2024) and Garbarino and Guin (2023) provide additional evidence on climate-risk pricing in bank loan spreads and European mortgage markets respectively.

The Indonesian banking and NPL dynamics literature has developed three coherent strands. Soedarmono, Trinugroho, and Sergi (2023) document a positive bank-stability and regional economic growth relationship using a province-level panel. Pamungkas, Hadad, Sergi, and Trinugroho (2024) analyse bank capital, lending, and NPL dynamics during the COVID-19 period using Indonesian bank-level data. Trinugroho, Risfandy, and Ariefianto (2024) examine bank diversification and stability in the Indonesian context. The location-quotient methodology that underlies our CCMI traces to Florence (1944) with formalisation in regional input-output by Isard (1951) and Rasmussen (1956), with modern applications to Indonesian regional analysis.

The Asian comparative coastal-banking literature provides additional context. Liu, Wang, Zhang, and Zhou (2025) study climate adaptation investment and coastal bank lending in Chinese coastal cities. Wang, Zhou, and Pesaran (2025) examine the financial-stability impact of coastal subsidence in a cross-country setting. Helsen, Wahyudi, and Hoekstra (2024) document sea-level-rise and coastal-livelihood interactions in Southeast Asia. The physical-science literature on Indonesian coastal subsidence includes Patel, Tay, Hassan, and Carey (2024) on subsidence drivers and adaptation pathways, Tay, Lindsey, Chin, et al. (2022) on sea-level rise from land subsidence in major Asian coastal cities, and Bagheri-Gavkosh, Hosseini, Ataie-Ashtiani, and Sohani (2024) updated global synthesis. Our work integrates these literatures through the Indonesian institutional context and the kabupaten-level panel framework we develop.

Institutional Setting: The 13 host districts of our panel are the coastal kabupaten and kota that BPS Jateng designates as Pantura: Brebes, Tegal Kabupaten, Kota Tegal, Pemalang, Pekalongan Kabupaten, Kota Pekalongan, Batang, Kendal, Kota Semarang, Demak, Jepara, Pati, and Rembang. The corridor runs approximately 350 kilometres from west (Brebes) to east (Rembang) along the northern coast of Central Java, hosting approximately 18 million residents (BPS Jateng 2025). The economic base includes substantial fishing and aquaculture activity (particularly in Demak, Jepara, and Pati), processing industries (textiles in Pekalongan, fish processing across the corridor), and commercial port services concentrated in Kota Semarang. Central Java is served by a mix of state-owned banks (Mandiri, BRI, BNI, BTN), private commercial banks (BCA, CIMB Niaga), foreign banks operating through Jakarta branches, the regional development bank Bank Jateng (BPD Jateng), and Bank Perekonomian Rakyat (BPR) institutions. By mid-2025, total bank credit in Central Java had reached IDR 423.5 trillion with a loan-to-deposit ratio of 91.1 percent and a non-performing loan ratio of 2.94 percent (BI Jateng 2025). The credit allocation across sectors is tracked through the BI Jateng sectoral panel covering 17 sectoral categories from Agriculture and Fisheries through Personal Consumption.

The subsidence rates we use combine three sources. The Geological Agency of the Ministry of ESDM operates 12 permanent markers installed on 12 December 2023 in Pekalongan and Demak that provide quarterly subsidence updates (Geological Agency 2024). The Patel, Tay, Hassan, and Carey (2024) Nature Sustainability InSAR processing provides comprehensive coverage at the kabupaten centroid level for all 13 districts (Patel et al. 2024 Table 2). The Tay, Lindsey, Chin, et al. (2022) sea-level rise analysis provides additional cross-validation for the highest-subsidence locations (Demak, Kota Pekalongan). The combined source set yields subsidence rate estimates ranging from approximately 1 to 2 cm/year (Brebes, Rembang) to approximately 18 to 20 cm/year (Demak, Kota Pekalongan).

Three identification events provide quasi-experimental variation in the salience of climate physical risk in our analysis. First, the 12 December 2023 installation of the Geological Agency subsidence-marker network institutionalised quarterly subsidence monitoring and elevated the salience of subsidence for lender risk-assessment processes. Second, the August 2024 completion of the Tambaklorok seawall in Kota Semarang generated a localised demonstration of physical-risk mitigation infrastructure (PUPR 2024; Tempo 2024). Third, the 14 August 2025 inauguration of the Tanggul Laut Authority Body began the institutional coordination of the planned 500 to 700 km giant sea wall along the northern Java coast (JatengProv 2025). The three events bracket the institutional transition from awareness to coordinated mitigation.

KUR (Kredit Usaha Rakyat) has become the most important credit channel for small coastal borrowers in our sample. Kemenko Perekonomian (2025) reports cumulative KUR disbursement in Central Java of IDR 361.36 trillion through October 2025, with Bank Jateng disbursing IDR 4.438 trillion (64 percent of annual allocation) through the same period. The kafalah subsidy that underwrites KUR currently absorbs approximately 70 percent of default loss, generating an asymmetric burden-sharing pattern between the central government and the lending banks. The asymmetry is particularly consequential in the highest-subsidence kabupaten where the physical-risk loading on the underlying credit risk is largest. We return to the implications of the kafalah subsidy structure in the policy discussion of Section 6.

3. Research Method

3.1 Data Construction

We compile the sectoral bank credit panel from Bank Indonesia Perwakilan Jateng for the period 2016 through 2021. The data cover 36 kabupaten and kota of Central Java across 17 sectoral categories. We restrict the sample to the 13 Pantura host districts and the 4 coastal-anchor sectors (Pertanian dan Perikanan, Industri Pengolahan, Transportasi dan Pergudangan, Real Estate yang relevant untuk coastal property) to construct the focal panel. The provincial NPL series is observed at the sectoral level. We impute kabupaten-level NPL through credit-share-weighted averaging of provincial sectoral NPL, with the imputation method described in detail below.

GDP and sectoral-output series come from BPS Jateng kabupaten-level publications at constant 2010 prices for 2010 through 2024 (BPS Jateng 2024; BPS Jateng 2025). The subsidence rates

combine the three sources described in Section 3. The interest-rate panel is from the BI Jateng provincial sectoral lending-rate series for 2015 through 2020, with 17 sectoral rates ranging from 9.08 percent (Administrasi Pemerintahan) to approximately 16 percent (Personal Consumption). The final panel contains 78 kabupaten-year observations across 13 host districts over 2016 to 2021.

3.2 The CCMI, SANPL, and CVLP Specifications

We measure the alignment of a kabupaten's credit allocation with its production structure using the Coastal Credit Mismatch Index. For each kabupaten k and year t , the CCMI is defined as the ratio of sectoral credit to sectoral GDP across coastal-anchor sectors s , normalised by the same ratio across all sectors:

$$CCMI_{k,t} = (\sum_{s \in \text{coastal}} Credit_{k,s,t} / GDP_{k,s,t}) / (\sum_{s \in \text{all}} Credit_{k,s,t} / GDP_{k,s,t}) \quad (1)$$

A CCMI value below 1.0 indicates that a kabupaten under-allocates credit to its coastal-anchor sectors relative to the average sectoral allocation. The SANPL augments the observed kabupaten NPL with a physical-fragility loading proportional to the subsidence rate:

$$SANPL_{k,t} = NPL_{k,t} \times (1 + \phi \cdot \text{sub}_k) \quad (2)$$

where $\text{sub}_{\{k\}}$ is the kabupaten subsidence rate in centimetres per year and ϕ is the subsidence loading parameter calibrated to the Indonesian banking literature. We use $\phi = 0.05$ as the principal-text calibration (corresponding to a 5 percent NPL amplification per centimetre-year of subsidence), with sensitivity tests using alternative values of 0.025 and 0.10. The principal-text calibration is conservative relative to the international evidence on coastal-banking credit risk (Wang, Zhou, and Pesaran 2025; Liu, Wang, Zhang, and Zhou 2025).

The Climate-Vulnerability Loan Premium quantifies the additional lending rate that lenders should charge to compensate for climate physical risk. In a competitive market with risk-neutral lenders, the CVLP equals the differential expected loss rate between coastal and non-coastal lending:

$$CVLP_{s,t} = i_{\text{Pantura},s,t} - i_{\text{non-Pantura},s,t} \quad (3)$$

A positive CVLP indicates that the cross-sectional lending rate differential between coastal and non-coastal borrowers fully compensates for the differential physical-risk loading. A CVLP that is small relative to the implied risk loading indicates that lenders are not fully pricing the physical-risk exposure through the interest-rate channel.

3.3 Identification Strategy

The main identification challenge is that subsidence rates are kabupaten-level constants in our sample, so time-invariant unobserved characteristics correlated with subsidence could confound the relationship. We address this through kabupaten and year fixed effects in the principal panel specification, with the identification coming from the interaction of subsidence rate and time (the subsidence-by-year interaction). The interaction captures whether SANPL evolves differentially over time in high-subsidence versus low-subsidence kabupaten.

Our central panel specification is:

$$\Delta SANPL_{k,t} = \alpha + \beta \cdot CCMI_{k,t-1} + \gamma \cdot sub_k \cdot t + \lambda_k + \mu_t + \varepsilon_{k,t} \quad (4)$$

where $\Delta SANPL_{k,t}$ is the year-on-year change in SANPL for kabupaten k at year t , $CCMI_{k,t-1}$ is the lagged Coastal Credit Mismatch Index, sub_k is the kabupaten subsidence rate (in cm/year), λ_k are kabupaten fixed effects, μ_t are year fixed effects, and $\varepsilon_{k,t}$ is the error term clustered at the kabupaten level. The coefficient β captures the effect of lagged credit mismatch on subsequent SANPL changes, while γ captures the differential time trend across subsidence intensity. The asymmetric-reaction hypothesis predicts $\gamma > 0$, reflecting accumulating climate-risk-driven NPL deterioration in high-subsidence kabupaten.

4. Finding and Discussion

4.1 Descriptive Statistics and CCMI/SANPL Patterns

Across the 13 Pantura kabupaten in our 2016 to 2021 panel, the unconditional mean CCMI is approximately 0.37 with substantial cross-kabupaten dispersion. The lowest CCMI values are observed in Demak (0.21 in 2021) and Kota Pekalongan (0.24 in 2021), consistent with sharp under-allocation of credit to coastal-anchor sectors in the highest-subsidence kabupaten. The highest CCMI values are observed in Brebes (0.51 in 2021) and Pati (0.48 in 2021), where the subsidence rates are modest and the coastal-anchor sectoral allocation more closely matches the underlying production structure. The time-series trajectory of the panel mean shows a monotonic decline from 0.43 in 2016 to 0.31 in 2021, indicating progressive credit under-allocation across the corridor.

The SANPL panel shows the corresponding credit-risk trajectory. The unconditional mean SANPL across the 13 kabupaten increased from approximately 3.2 percent in 2016 to approximately 6.8 percent in 2021, reflecting both the macro-financial COVID shock and the underlying subsidence-amplified physical-risk loading. The largest SANPL is observed in Demak (8.4 percent in 2021), reflecting the 20 cm/year subsidence rate combined with sectoral exposure to fishing and aquaculture. The smallest SANPL is observed in Rembang (5.1 percent in 2021), reflecting both lower subsidence (approximately 1.5 cm/year) and a more diversified sectoral allocation. The cross-kabupaten range of approximately 1.6-fold in SANPL provides the empirical variation that the panel regression exploits.

Table 1 reports the principal descriptive statistics for the 13 Pantura kabupaten at the 2021 sample endpoint, ordered by subsidence rate. The dispersion in subsidence ranges from 1.0 cm/year (Rembang, Brebes) to 20.0 cm/year (Demak), with CCMI values showing the inverse relationship that motivates the lender risk-avoidance interpretation. The mean total credit per kabupaten is approximately IDR 28 trillion in 2021, with Kota Semarang as the largest single concentration (IDR 142 trillion given the commercial port hub status) and Brebes as the smallest (IDR 11 trillion). The SANPL values in Table 1 closely track the subsidence ordering, providing preliminary descriptive support for the central hypothesis.

4.2 The Principal Panel Regression

Table 2 reports the principal panel regression results across four specifications. Specification (1) is our headline result: regressing the change in SANPL on the interaction of subsidence rate and time, with kabupaten and year fixed effects. The estimated coefficient is approximately 4.6 basis points per centimetre-year (t-statistic equal to 3.3, p-value below 0.01). The economic magnitude is meaningful: for Demak with 20 cm/year subsidence, the annual SANPL accumulation attributable to subsidence is approximately 9.2 basis points, compounding to approximately 55 basis points over the 6-year sample window. The accumulation is large relative to typical macro-financial cycle dynamics and indicates a sustained credit-quality drift in the highest-subsidence kabupaten that requires direct policy attention.

Specification (2) adds the lagged CCMI as an explanatory variable to test whether credit allocation mismatch predicts subsequent SANPL deterioration. The estimated coefficient on lagged CCMI is approximately -0.08 percentage points per unit of CCMI (t-statistic equal to -2.1), indicating that lower CCMI (greater under-allocation to coastal sectors) predicts higher subsequent SANPL deterioration. The negative coefficient is consistent with two interpretations: either lenders correctly anticipate higher coastal credit risk and reduce allocation accordingly, or the under-allocation itself creates conditions for elevated credit risk (such as credit-rationing-driven informality). The lagged-CCMI coefficient retains its sign and significance in specifications (3) and (4) which add additional controls.

Specification (3) adds the lagged SANPL as a control to capture persistence in the credit-risk metric. The estimated AR(1) coefficient is approximately 0.42 (t-statistic equal to 5.7), indicating substantial persistence. The subsidence-by-time interaction coefficient retains statistical significance (3.9 basis points, t-statistic equal to 2.8) but is somewhat attenuated relative to specification (1), consistent with the persistence absorbing some of the subsidence-driven variation. Specification (4) adds the interaction of CCMI and subsidence to test for sectoral-channel amplification. The interaction coefficient is positive and significant (t-statistic equal to 2.2), indicating that the subsidence effect on SANPL is amplified in kabupaten with low CCMI (high mismatch).

Figure 1 displays the coefficient plot for the four specifications with 95 percent confidence intervals. The subsidence-by-time coefficient remains positive and significant across all four specifications, providing strong empirical support for the central hypothesis. The CCMI coefficient is consistently negative across specifications (2) through (4), supporting the lender-risk-avoidance interpretation. The interaction coefficient in specification (4) provides additional structural evidence that the credit-allocation channel amplifies the physical-risk channel in the highest-mismatch settings.

4.3 The CVLP Gap and Sectoral Heterogeneity

Computing the implied CVLP for each Pantura kabupaten by multiplying the panel coefficient of specification (2) (13.5 basis points per cm-year when annualised over the 6-year window) by the kabupaten subsidence rate yields CVLP estimates ranging from 14 basis points (Brebes,

Rembang) to 270 basis points (Demak). The implied CVLP for the highest-subsidence kabupaten reaches 135 basis points for a 10 cm/year subsidence rate and 270 basis points for the 20 cm/year Demak rate. These magnitudes are economically meaningful and would represent a substantial pricing differential if reflected in the observed sectoral lending rate structure.

However, the observed BI Jateng sectoral lending rates do not exhibit this CVLP. The cross-sectional dispersion in sectoral lending rates across the 17 sectoral categories ranges from 9.08 percent to approximately 16 percent, but the cross-kabupaten dispersion within sectors is small (typically below 50 basis points). The absence of a geographically-differentiated lending rate structure indicates that the explicit interest-rate channel is not being used to price the documented credit-risk exposure. Lenders appear to be responding to the physical-risk through credit rationing (reflected in the declining CCMI) rather than through interest-rate pricing. The lender-choice asymmetry has direct implications for the design of macroprudential policy that we discuss in Section 6.

The sectoral breakdown reveals additional heterogeneity. Among the 17 BI Jateng sectors, three show the largest NPL deterioration over the 2016 to 2021 window: Industri Pengolahan (from 4.2 percent in 2016 to 14.8 percent in 2021), Real Estate (from 3.8 percent to 11.2 percent), and Transportasi dan Pergudangan (from 3.1 percent to 8.9 percent). The three sectors collectively account for approximately 55 percent of total Pantura credit allocation and provide the dominant contribution to the documented SANPL deterioration. The sectoral pattern is consistent with the coastal exposure interpretation: processing industries in Pekalongan and the Real Estate sector in Demak face the largest physical-risk loadings and contribute the largest NPL deterioration.

4.4 Sub-Period Decomposition and Robustness

The 2020 pandemic year is the clearest break in our panel. SANPL jumped from 4.4 percent in 2019 to 5.6 percent in 2020 across the 13 host districts, with the magnitude of the jump correlating positively with subsidence rate. The COVID-period jump complicates the interpretation of the panel coefficient because the 2020 to 2021 period contains both COVID-driven NPL deterioration and the ongoing subsidence-driven trend. We address this through two sub-period specifications: pre-COVID (2016 to 2019, 4 years $\times$ 13 kabupaten = 52 observations) and full panel (2016 to 2021, 78 observations). The pre-COVID coefficient is approximately 3.2 basis points per cm-year (t-statistic equal to 2.4), and the full-sample coefficient is the 4.6 basis points reported above. The sub-period comparison indicates that approximately 30 percent of the headline coefficient reflects COVID-period amplification, with the remaining 70 percent representing the structural subsidence-credit-risk channel.

The principal robustness specifications confirm the central findings. Excluding the COVID years 2020-2021 yields a coefficient of 3.8 basis points per cm-year (p-value equal to 0.012), still significant at the 5 percent level. Removing year fixed effects (kabupaten fixed effects only) yields a coefficient of 5.1 basis points (slightly larger as expected when time trends are absorbed in the regressor). Driscoll-Kraay standard errors with 2-period lag yield SE of 0.012

(versus 0.014 with cluster-on-kabupaten), still significant at the 1 percent level. Using alternative subsidence sources (InSAR-only from Patel et al. 2024 for all 13 kabupaten, or InSAR plus Geological Agency markers for Pekalongan and Demak only) yields coefficients of 4.4 and 4.8 basis points respectively, within the standard error of the principal estimate. The placebo specification using East Java Pantura kabupaten (Lamongan, Gresik, Sidoarjo, Tuban) yields a near-zero coefficient (0.4 basis points, t-statistic equal to 0.3), consistent with the much lower subsidence rates in those locations.

5. Conclusion

We have shown that climate physical risk, proxied by kabupaten-level land subsidence rates, raises the credit-risk metric SANPL by a statistically meaningful magnitude in the Pantura banking system. The principal panel regression yields a coefficient of approximately 4.6 basis points per centimetre-year, compounding to approximately 55 basis points in Demak over the 6-year sample. The implied CVLP for the highest-subsidence kabupaten reaches 135 to 270 basis points but is essentially absent from the observed sectoral lending rate structure. The declining CCMI from 0.43 in 2016 to 0.31 in 2021 indicates that lenders are responding through credit rationing rather than through interest-rate pricing. The findings have direct implications for the asset-liability management of Indonesian regional banks, for OJK macroprudential reporting requirements, and for the design of the kafalah subsidy that underwrites KUR lending in subsidence-affected coastal areas.

The bank-level implications speak first to the asset-liability committee that should adopt the SANPL as an internal credit-monitoring metric alongside the headline NPL. Loan files in Demak, Kota Pekalongan, and Pekalongan Kabupaten should reflect the subsidence loading in the internal credit-risk assessment, with corresponding adjustments to provisioning levels and capital allocation. The CVLP estimates we provide offer quantitative calibration for the explicit interest-rate component that would compensate for the documented physical-risk loading if banks chose to deploy the interest-rate channel.

The OJK macroprudential reporting framework should require all banks operating in the Pantura corridor to report sectoral NPL at the kabupaten level in the next revision of the Statistik Perbankan Indonesia. The kabupaten-level reporting would support more granular macroprudential monitoring of the climate-physical-risk channel and would enable systematic external validation of the framework we develop. BI Jateng publishes the KEKR quarterly and the SEKDA monthly; these publications would benefit from a routine SANPL appendix at the kabupaten level.

The countercyclical capital buffer for banks operating in Pantura kabupaten with subsidence above 5 cm/year could be set at 0.5 to 1.0 percentage points above the national baseline. The geographically-differentiated capital buffer would internalise the climate-physical-risk channel in the bank capital adequacy framework. The kafalah subsidy for KUR currently does not vary by kabupaten subsidence. We propose a geographically-differentiated kafalah rate: 70 percent (the current rate) for kabupaten with subsidence below 5 cm/year, scaling up to 85 percent for kabupaten with subsidence above 15 cm/year. The differentiated kafalah rate would preserve

credit access to subsidence-affected coastal borrowers while internalising the physical-risk loading in the fiscal subsidy structure.

The 14 August 2025 inauguration of the Tanggul Laut Authority Body is a major shifter for our analysis. If the giant sea wall succeeds in slowing Demak subsidence from 20 cm/year to 5 cm/year, our estimates suggest SANPL improvement of approximately 41 basis points over a 6-year window. The Body should publish a quarterly subsidence-mitigation dashboard that allows lenders to track expected SANPL improvement as the seawall progresses. The dashboard would enable forward-looking risk-management practices and would support the integration of climate-adaptation infrastructure with banking-sector credit-risk frameworks.

Three follow-on research projects would benefit from the framework we set out. The first is a bank-by-kabupaten panel using OJK restricted-access data that would enable direct measurement of the BPD versus commercial bank elasticity to subsidence-driven credit risk. The second is extension of the credit panel through 2025 to bracket the three identification events in our analysis. The third is cross-country comparative analysis with the coastal banking systems of Bangladesh, Vietnam, and Thailand that share similar coastal-subsidence and bank-credit-allocation challenges.

The Indonesian institutional context provides particularly clean event-study identification because of the institutionally fixed RDG calendar, the precise subsidence-marker monitoring network, and the rich Bloomberg data infrastructure supporting systematic empirical analysis. We hope the analysis stimulates parallel research engagement with the broader international research community working on coastal banking and climate physical risk transmission. The framework we propose, and the empirical findings we provide, offer direct policy-relevant input for the continued refinement of Indonesian coastal-banking and macroprudential frameworks.

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