Climate-Related Financial Risks: Taxonomy, Transmission, and Materiality

Module 4: Green Finance Risk Management, Lesson 1

GREEN FINANCE Consortium

Erasmus+ CBHE Project 101237817

2026

Outline

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Learning Objectives

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Participants are able to:

1. **Classify** climate risks into physical, transition, and liability categories with precise sub-classifications
2. **Map** transmission channels linking climate events to financial losses through credit, market, operational, and liquidity pathways
3. **Distinguish** short-, medium-, and long-term risk horizons and their implications for portfolio management
4. **Apply** double materiality (financial vs. impact) to sectoral analysis across ASEAN economies
5. **Assess** Vietnam Mekong Delta climate vulnerability for bank portfolios using structured frameworks

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This is the Foundation-level entry point for Module 4. No prior knowledge of climate science or risk management is assumed.

Why Could a Central Banker Not Sleep at Night?

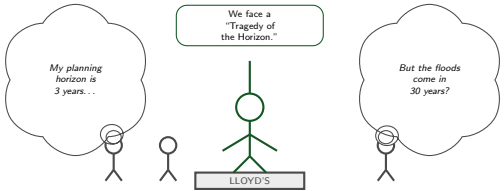
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Situation: In 2015, Bank of England Governor Mark Carney gives a speech at Lloyd's of London to an audience of insurers and bankers.

Complication: He warns that climate change threatens financial stability, but the worst impacts fall **beyond** the planning horizon of every actor in the room.

- Central banks plan 2 to 3 years ahead
- Politicians think in 4 to 5 year election cycles
- CFOs focus on quarterly earnings
- But catastrophic climate impacts arrive in 10 to 30+ years

"The catastrophic impacts of climate change will be felt beyond the traditional horizons of most actors – imposing a cost on future generations that the current generation has no direct incentive to fix."



The tragedy: everyone's horizon is shorter than the risk. Who bears the cost?

Source: Carney, M. (2015). Breaking the tragedy of the horizon: climate change and financial stability. Bank of England.

Climate Losses Are Already Financial Losses

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Global Economic Losses from Natural Disasters

- **2023:** ∼$250 billion in global economic losses from natural disasters (Munich Re; insured losses ∼$95 billion)
- **2011:** Thailand floods alone caused $15 billion in insured losses; 800+ factories inundated
- **2021:** Typhoon Rai, $2.1B damage in Philippines, 2M homes damaged
- **Trend:** Inflation-adjusted disaster costs have increased 3x since the 1980s

These are **realized** losses from *today's* climate. Projected warming of +1.5 to 3.0°C by 2050 will amplify frequency and severity.

Why This Is a Systemic Risk

- Climate risk is **correlated**: a single typhoon hits thousands of borrowers simultaneously
- Climate risk is **non-diversifiable**: every sector and geography is exposed
- Climate risk is **non-linear**: tipping points create sudden, irreversible losses
- Climate risk is **forward-looking**: historical data understates future exposure

Key Insight

Unlike credit or market risk, climate risk cannot be hedged away through diversification. It is a **systemic** risk that affects the entire financial system simultaneously.

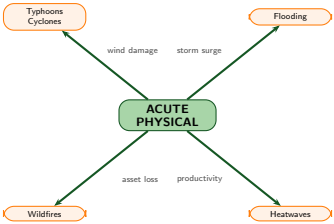
Sources: Munich Re NatCatSERVICE (2024); Swiss Re Institute sigma reports; Battiston et al. (2017).

Acute Physical Risks: Sudden, Severe, Concentrated

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Event-driven hazards that cause **immediate** damage to assets, infrastructure, and supply chains.

- **Typhoons and cyclones**: wind damage, storm surge, rainfall-induced flooding
- **Flooding**: riverine overflow, flash floods, coastal inundation
- **Wildfires**: direct asset destruction, air quality impacts on productivity
- **Heatwaves**: labor productivity losses, increased energy demand, crop failure



Financial channels: Insurance claims (immediate), collateral damage (credit risk), supply chain disruption (operational risk), deposit withdrawals in affected regions (liquidity risk).

ASEAN Example: Typhoon Rai (Super Typhoon Odette) struck the Philippines in December 2021: $1.1B insured losses, $2.1B total damage, 400+ deaths, 2M homes damaged, severe agricultural disruption in Visayas and Mindanao.

Acute risks are insurable in principle but increasingly uninsurable in practice as frequency and severity rise.

Chronic Physical Risks: Slow, Pervasive, Irreversible

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Long-term shifts in climate patterns that **gradually** erode asset values and economic productivity. Slower-moving but often more pervasive and harder to reverse than acute events.

Chronic Risk	Mechanism	Financial Impact
Sea-level rise	Coastal erosion, permanent inundation, saltwater intrusion into groundwater	Real estate devaluation, infrastructure retreat costs, sovereign downgrade risk
Temperature shift	Agricultural yield changes, cooling cost increases, species migration	Crop loan defaults, energy cost inflation, tourism revenue decline
Precipitation changes	Drought frequency, water scarcity, altered hydropower output	Water-intensive industry losses, hydropower revenue volatility, food price inflation

ASEAN Example: Vietnam's Mekong Delta. Saltwater intrusion currently reaches 60 to 90km inland during dry seasons, projected to extend 40 to 50km further by 2050. Under a 1-meter sea-level rise scenario, approximately 40% of the Delta is at risk of permanent inundation.

Chronic risks are often uninsurable. They require portfolio-level strategic adjustment, not event-by-event hedging.

Transition Risks: The Cost of Moving to a Low-Carbon Economy

[FOUNDATION]

Risks arising from the **adjustment toward a lower-carbon economy**. The speed, scale, and coordination of the transition determine the magnitude of financial losses.

1. **Policy & Legal**: Carbon pricing (taxes, ETS), emission reduction mandates, energy efficiency standards
2. **Technology**: Renewable cost declines rendering fossil assets obsolete, battery breakthroughs, green hydrogen
3. **Market**: Shifting consumer preferences, commodity price volatility, reduced fossil fuel demand
4. **Reputation**: Investor divestment campaigns, consumer boycotts, recruitment challenges for high-carbon firms
5. **Behavioral**: ESG-driven capital allocation, green procurement policies, lifestyle shifts

Key Distinction

Physical risks increase with **warming**. Transition risks increase with **policy ambition**. An "orderly" transition has lower transition risk; a "hot house" world has lower transition risk but extreme physical risk.

The five transition channels are adapted from TCFD (2017). The behavioral channel is an extension increasingly recognized by NGFS.

Stranded Assets: When the Transition Makes Assets Worthless

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What Are Stranded Assets?

Assets that suffer unanticipated or premature write-downs due to climate-related policy, technology, or market changes.

- **Fossil fuel reserves** that cannot be burned within carbon budgets
- **Coal-fired power plants** retired before end of economic life
- **Internal combustion engine factories** disrupted by EV mandates
- **Carbon-intensive real estate** failing new efficiency standards

Dietz et al. (2016) estimate the "climate value at risk" of global financial assets along a business-as-usual path at $2.5T in expectation, which is 1.8% of assets, rising to $24.2T at the 99th percentile, which is 16.9%.

ASEAN Transition Exposure

EU CBAM (phasing in from 2026):
Imposes carbon costs on imports of cement, iron, steel, aluminum, fertilizers, electricity, and hydrogen.

ASEAN impact:
- Vietnam's steel sector faces significant cost increases
- Thailand's cement industry exposed
- Indonesia's aluminum exports affected

Exporters must demonstrate low-carbon production or pay the carbon border adjustment.

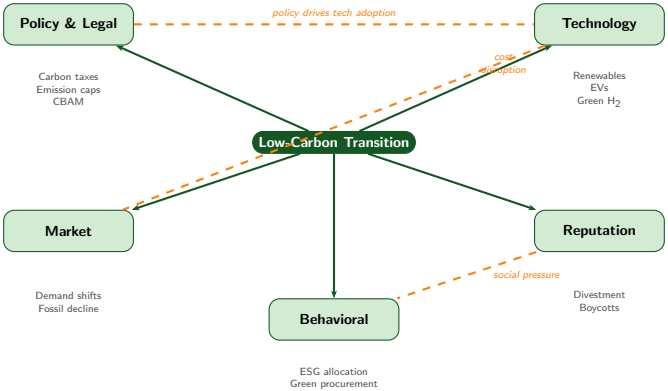
Key Insight

ASEAN countries face "double exposure": transition costs from **domestic** decarbonization policies *plus* border adjustments from **trading partner** policies (EU CBAM, potential US carbon tariffs).

Source: Dietz et al. (2016). Climate value at risk of global financial assets. Nature Climate Change, 6, 676 to 679.

How Do the Five Transition Channels Interact?

[INTERMEDIATE]



Transition channels interact and amplify each other. Policy mandates accelerate technology adoption; reputation pressure shifts market demand.

Liability Risks: The Courtroom as a Climate Transmission Channel

[FOUNDATION]

The emerging **third category** of climate risk, increasingly recognized as distinct from transition risks. Liability risks arise when parties seek compensation for climate-related losses through legal or regulatory action.

Three Sub-categories

- **Litigation**: Lawsuits against emitters for climate damages, failure to disclose climate risks, breach of fiduciary duty
- **Adaptation failure**: Legal liability for failing to adapt infrastructure or products to known climate risks (e.g., building in flood zones)
- **Greenwashing**: Regulatory enforcement and civil litigation against misleading environmental claims in financial products

The Numbers

- **2,341 cases** in the Sabin Center databases (Setzer & Higham, 2023)
- Exponential growth since 2015
- 70% of cases in the US, but ASEAN filings increasing
- **Shell ruling (2021):** Dutch court ordered 45% emissions reduction by 2030

Key Insight

Litigation risk creates a **contingent liability** that is hard to quantify but potentially enormous. Courts can mandate emissions reductions with binding financial consequences.

Source: Setzer, J. & Higham, C. (2023). Global Trends in Climate Change Litigation: 2023 Snapshot. Grantham Research Institute, LSE.

Climate Litigation Is Growing Exponentially

[INTERMEDIATE]

Four Litigation Categories

1. **Climate-aligned**: Cases seeking stronger climate action: emission reduction orders, policy challenges, corporate accountability
2. **Climate-obstructive**: Challenges to climate regulations: ETS validity disputes, stranded asset compensation claims
3. **Disclosure-based**: Shareholder suits for inadequate climate risk disclosure: securities fraud, fiduciary duty breach
4. **Greenwashing**: Consumer and regulatory actions against misleading ESG claims

Financial System Implications

- **Direct liability** for portfolio companies (lender liability theory)
- **Failure to disclose** climate risks to investors (securities law)
- **Greenwashing** in sustainable finance products (consumer protection)
- **Fiduciary duty**: fund managers who ignore climate risk face legal exposure

ASEAN relevance: While most cases originate in the US and EU, the Shell precedent signals growing global risk. ASEAN financial institutions with upstream oil & gas exposure face increasing litigation tail risk.

Litigation risk is shifting from idiosyncratic (individual lawsuits) to systematic (affecting entire sectors and asset classes).

Climate Risk Taxonomy: The Complete Classification

[FOUNDATION]

Category	Sub-type	Examples	Financial Channel	Time Horizon
Physical	Acute	Typhoons, floods, wildfires, heatwaves	Insurance claims, collateral damage	Short
	Chronic	Sea-level rise, temperature shift, precipitation change	Asset devaluation, yield decline	Medium to Long
Transition	Policy & Legal	Carbon taxes, ETS, CBAM, regulations	Compliance costs, stranded assets	Short to Medium
	Technology	Renewable disruption, EV adoption	Asset obsolescence, capex needs	Medium
	Market & Rep.	Demand shifts, divestment, boycotts	Revenue decline, cost of capital	Short to Medium
Liability	Litigation	Emission lawsuits, fiduciary duty claims	Contingent liabilities, settlements	Medium to Long
	Adaptation	Infrastructure failure claims	Damages, regulatory fines	Medium
	Greenwashing	Misleading ESG claims	Fines, reputational loss	Short

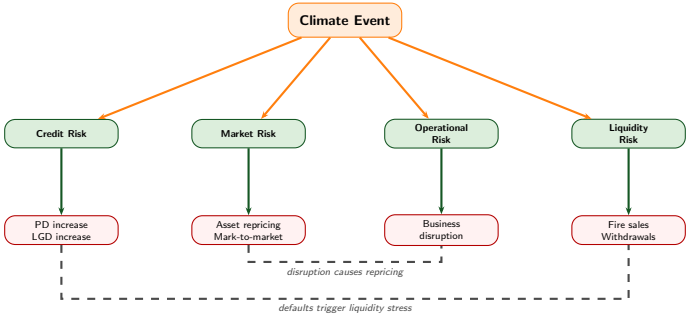
This taxonomy is adapted from Carney (2015), refined by TCFD (2017), and extended to include liability risks as a distinct category following Setzer & Higham (2023).

Every later lesson in Module 4 builds on these categories and channels.

How Do Climate Events Become Financial Losses?

[FOUNDATION]

Transmission channels describe **how** climate events propagate into financial losses. A single climate event can trigger losses through multiple channels simultaneously.



Critical insight: Transmission channels are **not independent**. Credit losses trigger liquidity stress; operational disruption causes market repricing. This cross-channel interaction is what makes climate risk systemic.

Transmission channels adapted from NGFS (2022) and BIS (2021). Cross-channel interactions create non-linear amplification.

Credit Risk: The Largest Transmission Channel for Banks

[FOUNDATION]

How Climate Affects Credit Risk

Climate events reduce borrower income or collateral values, increasing both probability of default (PD) and loss given default (LGD).

- **Income channel:** drought destroys crops → farmer cannot repay agricultural loan
- **Collateral channel:** flooding damages property → LGD increases as recovery value falls
- **Concentration risk:** banks with geographically concentrated loan books face correlated defaults

Climate-Adjusted Expected Loss

The standard credit risk formula can be extended to incorporate climate effects:

$$EL_{climate} = PD_{adj} \times LGD_{adj} \times EAD$$

where:

- $PD_{adj} = PD_{base} \times (1 + \Delta T \cdot \beta_{climate})$
- $LGD_{adj} = LGD_{base} + \Delta LGD_{physical}$
- $\beta_{climate}$ = sector-specific climate sensitivity
- ΔT = temperature change scenario

Key Insight

Climate adjustment can increase expected loss by **30 to 100%** for exposed sectors under a +2°C scenario (Battiston et al., 2017).

Credit risk is the primary transmission channel for commercial banks, which dominate ASEAN financial systems (70 to 90% of total financial assets).

Insurance and Asset Management: Two More Transmission Channels

[FOUNDATION]

Insurance Channel

- **Underwriting losses**: rising claims from acute physical events exceed premium income
- **Uninsurability**: some regions become too risky to insure at any price (e.g., Florida coastal, parts of Mekong Delta)
- **Protection gap**: in ASEAN, only 5 to 10% of disaster losses are insured (vs. 40 to 60% in developed markets)
- **Feedback loop**: insurance withdrawal forces banks to absorb uninsured credit losses

The insurance channel acts as a **shock absorber** in developed markets but barely exists in most of ASEAN, transferring risk directly to the banking sector.

Asset Management Channel

- **Portfolio repricing**: sudden recognition of climate risk triggers mark-to-market losses across asset classes
- **Stranded assets**: fossil fuel equities and bonds lose value as transition accelerates
- **Fire-sale dynamics**: coordinated ESG divestment depresses prices, imposing losses on remaining holders
- **Sovereign risk**: climate-vulnerable nations face higher borrowing costs, affecting all local-currency assets

Key Insight

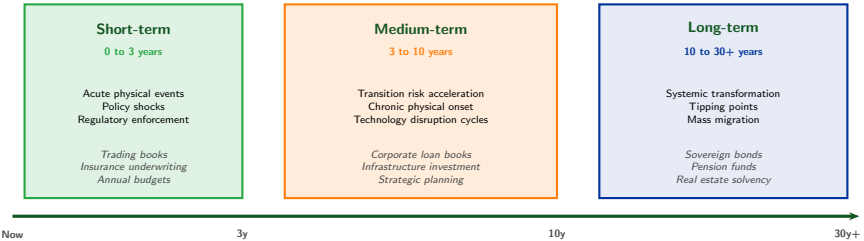
2011 Thailand floods: 800+ factories inundated. Thai banks faced simultaneous credit risk (NPLs), operational risk (branch closures), and liquidity risk (deposit withdrawals). Insured losses exceeded $15B.

ASEAN's low insurance penetration means banks absorb climate losses that insurers cover in developed markets. This is a structural vulnerability.

The Tragedy of the Horizon: Three Timescales of Climate Risk

[FOUNDATION]

Climate risks operate across fundamentally different timescales, creating a **mismatch** with traditional financial planning horizons.



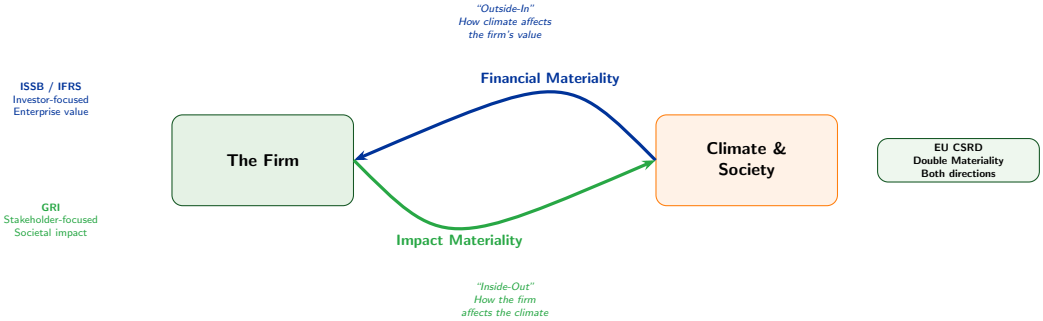
The mismatch: Most financial actors plan 1 to 5 years ahead. The worst climate impacts materialize in 10 to 30+ years. This temporal mismatch is Carney's "tragedy of the horizon": no one has the incentive to act until it is too late.

Source: Carney (2015). Vietnam's 30-year infrastructure bonds illustrate compounding risk across all three horizons.

Financial Materiality vs. Impact Materiality

[FOUNDATION]

Materiality determines **which climate risks matter enough to require action**. Three competing frameworks define materiality differently.



EU CSRD combines both lenses: a climate risk is material if it affects firm value **or** if the firm affects climate outcomes. This is the most comprehensive framework and the direction of ASEAN regulatory convergence.

Under double materiality, a Vietnamese coal plant with strong domestic demand still faces material risk through its climate impact.

Double Materiality: Why It Changes Everything for ASEAN Banks

[INTERMEDIATE]

Single Materiality (ISSB)

- Only risks affecting enterprise value are material
- A bank lending to coal plants may see **low** financial materiality if domestic demand remains strong
- Focus: cash flows, asset values, investor decisions
- Scope: narrower, easier to quantify

Double Materiality (EU CSRD)

- The bank's **financed emissions** are also material regardless of financial impact
- Both directions require disclosure and risk management
- Focus: enterprise value **plus** societal impact
- Scope: broader, harder to quantify

Why This Matters for ASEAN

Example: Vietnamese coal-fired power plant.
Financial materiality: Low in short term (strong domestic demand, government-backed PPAs).
Impact materiality: Very High (significant CO_2 emissions, affecting global climate).
Double materiality: **Both** dimensions require disclosure and management.

Key Insight

As ASEAN regulators increasingly adopt EU-aligned standards (Thailand SEC, Vietnam SSC), the scope of material climate risks will expand substantially. Banks must prepare for double materiality **now**, even if it is not yet legally mandated.

Double materiality is the direction of global convergence. ASEAN institutions that prepare early will have a competitive advantage.

Climate-Adjusted Expected Loss: The Core Formula

[FOUNDATION]

The standard credit risk expected loss formula can be extended to incorporate climate effects systematically:

$$EL_{climate} = \underbrace{PD_{base} \times (1 + \Delta T \cdot \beta_{climate})}_{\text{climate-adjusted PD}} \times \underbrace{LGD_{base} + \Delta LGD_{physical}}_{\text{climate-adjusted LGD}} \times EAD$$

Parameter definitions:

- PD_{base}: baseline probability of default (historical)
- ΔT: temperature change scenario (+1.5°C, +2.0°C, +3.0°C)
- $\beta_{climate}$: sector-specific climate sensitivity coefficient (from NGFS damage functions)
- LGD_{base}: baseline loss given default
- $\Delta LGD_{physical}$: additional collateral impairment from physical damage
- EAD: exposure at default

What makes this "forward-looking":

- Traditional PD uses historical default rates
- Climate-adjusted PD incorporates **scenario-based** projections
- $\beta_{climate}$ varies by sector: agriculture ($\sim$0.35), energy ($\sim$0.25), technology ($\sim$0.05)
- Temperature scenarios come from NGFS pathways
- This shifts credit risk from "what happened" to "what will happen"

Key Insight

Historical risk models **systematically understate** climate risk because the past is not a reliable guide to a non-stationary climate future.

This formula is the bridge between climate science and credit risk. Lesson 4.5 (Stress Testing) will apply it at portfolio scale.

Worked Example: Climate VaR for an ASEAN Agricultural Loan

[INTERMEDIATE]

Apply the climate-adjusted expected loss formula to a Vietnamese bank's agricultural portfolio in the Mekong Delta under a +2.0°C scenario.

Input Parameters

Parameter	Value
PD_{base} **(agriculture)**	5.0%
ΔT **(scenario)**	+2.0°C
$\beta_{climate}$ **(agriculture)**	0.35
LGD_{base}	60%
$\Delta LGD_{physical}$	5% (flood damage)
EAD **(ag. portfolio)**	**$**300M

Step-by-step calculation:

$PD_{adj} = 0.05 \times (1 + 2.0 \times 0.35) = 0.085$

$LGD_{adj} = 0.60 + 0.05 = 0.65$

$EL_{climate} = 0.085 \times 0.65 \times 300 = \$16.6\text{M}$

Comparison: Climate vs. Baseline

Metric	Baseline	+2.0°C
PD	5.0%	8.5%
LGD	60%	65%
Expected Loss	**$**9.0M	**$**16.6M
Climate VaR Increase	n/a	**+$7.6M +84%**

The climate adjustment adds **$7.6M** (+84%) in expected losses for the agriculture sector alone. Across a 10-sector portfolio, the aggregate Climate VaR can reach 30 to 50% of baseline expected loss.

This is a simplified example. Lesson 4.4 (Carbon Metrics) and 4.5 (Stress Testing) develop the full multi-sector, multi-scenario methodology.

Sectoral Exposure: Which Sectors Are Most Vulnerable?

[INTERMEDIATE]

Sector	Physical Risk	Transition Risk	Liability Risk	Overall
Energy (fossil fuels)	High	Very High	High	**Very High**
Agriculture	Very High	Medium	Low	**Very High**
Real Estate	High	High	Medium	**High**
Transport	Medium	High	Medium	**High**
Manufacturing	Medium	High	Medium	**High**
Tourism	High	Medium	Low	**High**
Fisheries & Aquaculture	Very High	Low	Low	**High**
Mining	Medium	High	Medium	**Medium-High**
Financial Services	Low	Medium	Medium	**Medium**
Technology	Low	Low	Low	**Low**

Key pattern: Sectors face **different risk profiles**. Agriculture is dominated by physical risk. Energy is dominated by transition risk. Financial services face indirect exposure through all channels. A diversified bank needs sector-specific risk assessment, not a single climate risk score.

Sectoral exposure determines portfolio-level Climate VaR. Banks concentrated in agriculture and energy face the highest climate risk.

Compound Risks: When Climate Drivers Interact

[INTERMEDIATE]

Climate risks rarely occur in isolation. **Compound risk** analysis examines how multiple climate drivers interact to produce non-linear financial losses that exceed the sum of individual assessments.

Interaction Types

- **Physical + Physical**: Drought followed by flooding on hardened soil; heatwave + wildfire cascades
- **Physical + Transition**: Drought reduces output *while* carbon tax raises input costs (margin squeeze)
- **Transition + Transition**: Simultaneous EV disruption + emission standards accelerate stranding
- **Feedback loops**: Climate damage reduces fiscal capacity for adaptation, increasing future damage

ASEAN Compound Risk Example

Philippine agriculture faces:
(1) La Niña-driven typhoon season (acute physical)
(2) Rising fertilizer costs from carbon pricing (transition)
(3) Drought in alternative regions drives food imports higher (market)

For agricultural lenders, the **combined** probability of default far exceeds independent risk estimates.

Key Insight

Standard risk models assume independence. Compound risk analysis reveals that climate risks are **correlated**, producing losses 1.5 to 3x higher than independent estimates (NGFS, 2022).

Compound risk is a key research frontier. Traditional VaR models miss these interactions because they assume risk factor independence.

Vietnam's Mekong Delta: One of the World's Most Climate-Exposed Regions

[FOUNDATION]

Geographic and Economic Context

- **12 provinces** in southern Vietnam
- Home to **18 million people**
- Produces **50%** of Vietnam's rice output
- Generates **90%** of aquaculture exports
- Vietnam's agricultural heartland and one of the most climate-exposed economic zones in ASEAN

Why It Matters for Banks

Vietnamese commercial banks have significant loan book concentration in the Delta region. Agricultural loans, real estate mortgages, and SME lending all face climate-driven credit deterioration.

Climate Threats

- **Saltwater intrusion**: currently 60 to 90km inland during dry seasons; projected +40 to 50km by 2050
- **Sea-level rise**: under 1m rise scenario, ∼40% of Delta at risk of inundation
- **Increased flooding**: upstream hydropower + intense monsoon rainfall
- **Temperature increase**: projected +1.5 to 2.5°C by 2050, reducing rice yields by 10 to 20%

Key Fact

The Mekong Delta lies 0.5 to 2.0 meters above sea level. Even modest sea-level rise has catastrophic consequences for agriculture, infrastructure, and real estate.

Source: ADB (2021). Climate Risk Country Profiles: Southeast Asia. The Mekong Delta is a "canary in the coal mine" for ASEAN climate risk.

Case Study: Hypothetical Bank Portfolio in the Mekong Delta

[FOUNDATION]

Assess the climate risk exposure of a Vietnamese commercial bank with the following loan portfolio concentration in the Mekong Delta:

Sector	Portfolio Share	Primary Climate Risk	Transmission Channel
Agriculture	30%	Physical (saltwater intrusion, floods)	Credit: PD increase
Real Estate	20%	Physical (sea-level rise, inundation)	Credit: collateral devaluation
Manufacturing	15%	Transition (CBAM, energy costs)	Market: cost increase
Retail	15%	Physical (flooding, displacement)	Credit: income disruption
Energy	10%	Transition (decarbonization policy)	Market: stranded assets
Services	10%	Physical (heatwaves, flooding)	Operational: business disruption

Observation: 65% of the portfolio (agriculture + real estate + retail) is directly exposed to **physical** climate risks. An additional 25% (manufacturing + energy) faces significant **transition** risk. Only 10% (services) has moderate exposure.

Task: Classify all climate risks per sector, identify transmission channels, and assess materiality using the three-horizon framework.

Three-Horizon Assessment: How Climate Risk Compounds Over Time

[INTERMEDIATE]

Horizon	Timeframe	Key Risks (Mekong Delta)	Assessment Focus
Short	**0 to 3 years**	Typhoon damage, seasonal flooding, acute saltwater intrusion events	PD increase for agricultural loans, collateral damage, insurance gaps
Medium	**3 to 10 years**	Progressive saltwater intrusion, transition to saline-tolerant crops, infrastructure adaptation needs	Sectoral reallocation, real estate repricing, technology investment
Long	**10 to 30 years**	Permanent inundation risk, mass relocation, fundamental economic transformation of the Delta	Stranded real estate, sovereign risk, portfolio exit strategy

Compounding across horizons: Vietnam's 30-year infrastructure bonds financing Mekong Delta transport and energy projects face risk across *all three* horizons: immediate typhoon damage (short), saltwater intrusion reducing agricultural collateral value (medium), and potential uninhabitability of low-lying areas under high-warming scenarios (long).

The three-horizon framework forces analysts to look beyond quarterly results. Long-term risks are already priced by sophisticated investors.

Secondary Case: Philippines Typhoon Belt Exposure

[FOUNDATION]

Why the Philippines?

- About **20 tropical cyclones** form in the region per year; **8 or 9** cross the country
- Among the world's most disaster-prone countries
- Agriculture contributes 10% of GDP but employs 25% of workforce
- Low insurance penetration (<5% of disaster losses insured)

Typhoon Rai (Dec 2021)

- Category 5 super typhoon
- $2.1 billion total economic damage
- $1.1 billion insured losses
- 400+ deaths, 2 million homes damaged
- Visayas and Mindanao agricultural output severely disrupted

Banking Sector Implications

- **Credit risk:** Agricultural and SME loan defaults spike in affected provinces
- **Operational risk:** Branch networks damaged, ATM outages, staff displacement
- **Liquidity risk:** Deposit withdrawals for emergency spending
- **Concentration risk:** Banks with Visayas-heavy loan books face correlated losses

Comparison with Mekong Delta

Philippines: Dominated by **acute** physical risk (typhoons). Recurring, insurable in theory.
Vietnam: Dominated by **chronic** physical risk (saltwater intrusion). Progressive, largely uninsurable.
Different risk profiles require different management strategies.

The Philippines and Vietnam illustrate two contrasting ASEAN climate risk profiles: acute vs. chronic physical exposure.

Building a Climate Risk Heatmap: 10 Sectors × 6 Risk Types

[INTERMEDIATE]

A portfolio-level risk assessment tool: each cell scored 1 to 5 using NGFS scenario data and expert judgment.

Sector	Acute Phys.	Chronic Phys.	Policy Trans.	Tech Trans.	Market Trans.	Litigation
Energy	3	2	5	4	4	3
Agriculture	5	4	2	2	3	1
Real Estate	4	4	3	2	3	2
Transport	3	2	4	4	3	2
Manufacturing	2	2	4	3	3	2
Tourism	4	3	2	1	3	1
Fisheries	5	4	1	1	2	1
Forestry	4	3	3	2	2	2
Mining	3	2	4	3	3	3
Fin. Services	1	1	3	2	2	3

Portfolio-weighted risk score: $R_{\text{portfolio}} = \sum_{s=1}^{10} \sum_{r=1}^{6} w_s \cdot \text{Score}_{s,r}$ where w_s = portfolio weight of sector s.
Red zones (scores 4 to 5) require immediate risk management attention. The Quantitative Lab constructs this heatmap using Python + seaborn.

Scores are illustrative. In practice, calibrate from NGFS Phase IV scenarios and country-specific World Bank Climate Portal data.

Endogenous vs. Exogenous: Climate Risk as Systemic Risk

[PhD]

The Battiston et al. (2017) Insight

Climate risk is **not purely exogenous**. Financial network structure creates **endogenous amplification**: initial climate shocks propagate through interbank exposures, portfolio overlaps, and fire-sale dynamics.

Network Propagation Model:

$$R_i(t+1) = R_i(t) + \sum_j w_{ij} \cdot \Delta V_j(t)$$

where $R_i(t)$ = risk exposure of institution i at time t, w_{ij} = network weight (exposure of i to j), $\Delta V_j(t)$ = value change of institution j's portfolio from climate impacts.

Three Propagation Mechanisms

1. **Contagion**, direct counterparty exposure: institution j defaults from climate losses, i loses its claims on j
2. **Fire sales**, indirect: forced selling depresses prices, imposing mark-to-market losses on all holders
3. **Amplification**, positive feedback: losses $\rightarrow$ margin calls $\rightarrow$ more sales $\rightarrow$ lower prices $\rightarrow$ more losses

Research Question

Under what conditions does network amplification of climate shocks **exceed** the original exogenous loss? How does ASEAN interbank topology compare to EU networks in contagion vulnerability?

Source: Battiston, S., et al. (2017). A climate stress-test of the financial system. Nature Climate Change, 7, 283 to 288.

Climate Litigation: From Idiosyncratic to Systematic Risk

[PhD]

Taxonomy Evolution

Year	Framework	Contribution
2015	Carney / FSB	"Tragedy of the Horizon"; created TCFD
2017	TCFD	Four-pillar disclosure standard
2019	NGFS	Central bank scenario framework
2023	TNFD	Nature-related risks; LEAP approach
2024	ISSB	IFRS S2 global baseline (20+ jurisdictions)

Each framework **expanded** the scope of what counts as "climate risk," moving from physical/transition dichotomy to nature-inclusive, litigation-aware taxonomy.

Litigation as Systematic Risk

Setzer & Higham (2023) document **2,341 cases** in the Sabin Center databases, establishing litigation as a **systematic** risk.

- **Climate-aligned:** emission reduction orders, corporate accountability
- **Disclosure-based:** shareholder suits for inadequate risk disclosure
- **Greenwashing:** enforcement against misleading ESG claims

Research Question

How should financial institutions model the probability distribution of climate litigation outcomes, and what is the appropriate capital buffer for this emerging systematic risk in ASEAN jurisdictions?

Source: Setzer & Higham (2023); NGFS (2022). Climate litigation creates contingent liabilities that are difficult to quantify but potentially enormous.

Summary: What You Should Remember from Lesson 4.1

[FOUNDATION]

The Taxonomy

1. **Physical risks** = acute (events) + chronic (trends). Increase with warming.
2. **Transition risks** = policy, technology, market, reputation, behavioral. Increase with policy ambition.
3. **Liability risks** = litigation, adaptation failure, greenwashing. A case load that continues to grow.

The Transmission

- Four channels: credit, market, operational, liquidity
- Channels **interact**, not independent
- Credit is the dominant channel for ASEAN banks, whose balance sheets are loan-heavy

The Materiality

- Financial materiality: outside-in (ISSB)
- Impact materiality: inside-out (GRI)
- **Double materiality**: both directions (EU CSRD), the direction of global convergence

The Quantitative Core

- $EL_{climate} = PD_{adj} \times LGD_{adj} \times EAD$
- Climate adjustment can add **30 to 100%** to expected loss
- Historical models systematically understate climate risk

What's Next

Lesson 4.2 introduces TCFD/TNFD frameworks for **disclosing** these risks. You now know *what* the risks are; next you learn *how to report* them.

Before you can manage risk, you must classify it. The classification system is now in place, and Lessons 4.2 to 4.6 build the management toolkit.

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TCFD (2017). Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures. Financial Stability Board.

Supplementary References and Data Sources

ADB (2021). Climate Risk Country Profiles: Southeast Asia. Asian Development Bank.

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ISSB (2023). IFRS S2: Climate-related Disclosures. International Sustainability Standards Board.

Data Sources for Quantitative Lab

- NGFS IIASA Scenario Explorer: `https://data.ece.iiasa.ac.at/ngfs/`
- World Bank Climate Change Knowledge Portal: `https://climateknowledgeportal.worldbank.org/`
- NGFS Scenarios Portal: `https://www.ngfs.net/ngfs-scenarios-portal/`

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EACEA. Neither the European Union nor the granting authority can be held responsible for them.

Acknowledgments

Developed by the University of Twente as Module 4 of the GREEN FINANCE curriculum, under Work Package 3 of the Erasmus+ Capacity Building in Higher Education project GREEN FINANCE (Grant 101237817).

Use of generative AI

Generative AI was used as a writing and research assistant in preparing this module. The tool was Claude (Anthropic), versions Opus 4.8 and Opus 5, used from July 2026 to the submission of this module on 11 September 2026. Its use was confined to the following purposes:

- idea generation and brainstorming on module structure and worked examples;
- language editing of author-specified content;
- literature classification and organisation of the reading list;
- coding assistance for the chart, data-processing, and document-build scripts;
- interactive literature searching using AI-enhanced search tools.

The authors specified and reviewed the content of this module. Every cited source was checked against the original publication, and every figure states its provenance on its own face, distinguishing sourced values from derived values and from illustrative teaching assumptions. The authors remain fully responsible for the originality, accuracy, integrity, references, and conclusions of the material.

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