

Lesson 4.1

Climate-Related Financial Risks Taxonomy, Transmission, and Materiality

Module 4: Green Finance Risk Management

GREEN FINANCE Professional Certificate

Erasmus+ CBHE 101237817

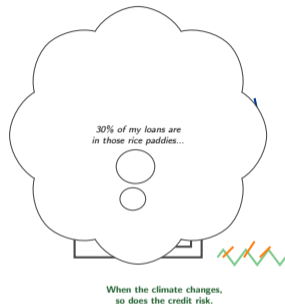
[FOUNDATION]

Situation: A regional bank in the Philippines holds 30% of its loan portfolio in Visayas agriculture and fisheries.

Complication: Super Typhoon Haiyan (2013) destroys collateral across 44 provinces in a single day.

Question: How should the bank have classified this exposure *before* the event?

- **\$12.9 billion** total damages from Typhoon Haiyan alone
- **50% of Vietnam's rice** comes from the Mekong Delta, increasingly threatened by saltwater intrusion
- **3.2% of GDP** lost annually to climate disasters in the Philippines



This is the problem we classify today – climate events becoming financial events.

Why Can't Traditional Risk Models Handle Climate?

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Traditional Risk

- Based on **historical data** – past predicts future
- **1–3 year** planning horizon
- **Known distributions** – Normal, log-Normal, Student-*t*
- Primarily **idiosyncratic** – diversifiable across sectors

Climate Risk

- **No precedent** – non-stationary, forward-looking only
- **30+ year** impact horizon (but shocks arrive now)
- **Fat tails** – extreme events more frequent than models predict
- Fundamentally **systemic** – correlated across sectors, geographies, time

Key Insight

Climate risk is not just another risk factor – it challenges the foundations of how we measure risk. Historical VaR, stress testing based on past crises, and mean-variance optimization all assume a stationary world.

Mark Carney (2015): 'The tragedy of the horizon' – climate risks fall outside the typical business cycle.

Road Map: Where Are We Going?

Section	Slides	Central Question
Introduction	1–4	What is the problem?
Context	5–9	What does climate risk look like in ASEAN?
Challenge	10–15	How do we classify climate–financial risks?
Analysis	16–24	How do we measure and map these risks?
Resolution	25–30	How do we apply the taxonomy to real portfolios?
Summary	31–33	What did we learn and where do we go next?

The lesson follows a **case-based** arc: we begin with a concrete ASEAN climate event, build the analytical framework to classify it, and end by applying the framework to a Vietnamese bank portfolio.

Lesson 4.1 of 6 in Module 4. Foundation level with Intermediate and PhD extensions.

What Does Climate Risk Look Like in Southeast Asia?

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Vietnam

- Mekong Delta: **40–50 km saltwater intrusion** projected by 2050
- **50% of national rice** production at risk
- Ho Chi Minh City subsidence: **2–5 cm/year**

Thailand

- 2011 floods: **\$46.5 billion** damages, global supply chain disruption
- Bangkok sinking at **1–2 cm/year**
- **10% of GDP** from agriculture exposed to drought

Philippines

- **20+ typhoons/year**; 5–8 make landfall
- **3.2% of GDP** annual loss from natural disasters
- Agriculture employs **25%** of workforce, highly exposed

Key Numbers

- ▷ ASEAN: **4 of top 10** most climate-vulnerable countries
- ▷ **\$90 billion/year** projected climate losses by 2030
- ▷ **80%** of ASEAN population lives within 100 km of coastline

ADB (2021): Southeast Asia is the most climate-vulnerable developing region.

How Do Climate Events Become Financial Losses?

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Step 1: Climate Event

- Typhoon makes landfall in Visayas
- Flooding destroys crops and infrastructure

Step 2: Real Economy Impact

- Rice harvest down 15%, fisheries disrupted
- Supply chains severed, local GDP contracts

Step 3: Borrower Distress

- Farmers cannot repay loans; collateral (land) devalued
- SMEs lose revenue, default probability rises

Step 4: Bank Loss

- Non-performing loans spike from 3% to 12%
- Provisions increase; capital adequacy ratio drops



The chain from climate to finance is the transmission mechanism we formalize next.

Three Families of Climate-Related Financial Risk

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Physical Risk

- **Acute:** typhoons, floods, wildfires, heatwaves
- **Chronic:** sea-level rise, temperature increase, changing precipitation
- Damages assets, disrupts operations, destroys collateral

Transition Risk

- **Policy:** carbon taxes, emission caps, fossil fuel phase-outs
- **Technology:** stranded assets from clean-tech disruption
- **Market:** shifting consumer preferences, reputational damage

Liability Risk

- **Direct:** climate litigation against polluters
- **Indirect:** D&O liability for inadequate disclosure
- 2,500+ cases globally and growing



This three-way taxonomy is the standard classification used by NGFS and central banks worldwide.

What Exactly Are Physical Risks?

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Acute Physical Risks (event-driven)

- Typhoons and cyclones (20+ per year in Western Pacific)
- Riverine and coastal flooding
- Droughts and heatwaves
- Wildfires (increasingly frequent in mainland SE Asia)

Chronic Physical Risks (trend-driven)

- Sea-level rise: **+0.3–1.0 m** by 2100 (IPCC AR6)
- Temperature: **+1.5–4.0°C** mean increase
- Precipitation pattern shifts and monsoon variability
- Ocean acidification threatening fisheries

Quantitative Framing

Indicator	ASEAN Projection
Saltwater intrusion	40–50 km by 2050
Rice yield loss	–10% to –25%
Flood frequency	×2–4 in deltas
Coastal inundation	20% of Bangkok

Key Insight

Chronic risks are harder to price because they unfold slowly. By the time they are observable, asset repricing may be too late – the “boiling frog” of climate finance.

Physical risks affect both the asset side (collateral damage) and liability side (insurance claims) of bank balance sheets.

What Exactly Are Transition Risks?

[FOUNDATION]

Five Categories of Transition Risk

- **Policy & Legal:** Singapore carbon tax (\$25/tCO₂, rising to \$50–80), Thailand carbon neutrality 2050 pledge
- **Technology:** Solar LCOE down 89% since 2010; coal plants become stranded assets
- **Market:** ESG fund flows redirecting capital; green bond premium (“greenium”)
- **Reputation:** Consumer boycotts, fossil fuel divestment campaigns
- **Stranded Assets:** \$1–4 trillion in fossil fuel assets at risk globally

ASEAN Transition Risk Summary

Type	ASEAN Example
Policy	SG carbon tax \$25 → \$80
Technology	Vietnam solar boom
Market	Green bond demand surge
Reputation	Palm oil divestment
Stranded	Coal pipelines at risk

The Transition Paradox

Faster transition = lower physical risk but higher transition risk. Slower transition = lower transition risk but catastrophic physical risk. There is no risk-free path.

Transition risks grow as the world moves toward net zero – the faster the transition, the sharper the risk.

[FOUNDATION] [PhD]

Three Types of Climate Liability

- **Failure-to-mitigate:** Lawsuits against high emitters for climate damages (e.g., Milieudefensie v. Shell, 2021)
- **Failure-to-adapt:** Claims against governments and firms for inadequate climate preparation
- **Failure-to-disclose:** Securities litigation for misleading climate risk statements

Scale: Over 2,500 climate litigation cases filed globally as of 2023, with cases doubling since 2017.

PhD Extension: Climate Litigation Frontier

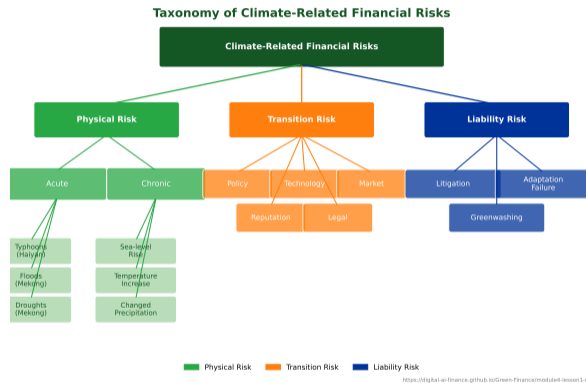
Setzer & Higham (2023) document the explosion of “climate-washing” litigation:

- Attribution science now links specific emissions to specific damages
- Courts increasingly accept climate models as evidence
- Financial institutions face D&O liability for inadequate climate governance
- ASEAN: Philippine Commission on Human Rights investigation of 47 carbon majors

PhD: Setzer & Higham (2023) document 2,500+ climate litigation cases – liability risk is no longer hypothetical.

How Does the Full Risk Taxonomy Fit Together?

[FOUNDATION]



- The taxonomy branches from **Climate-Related Financial Risk** into Physical, Transition, and Liability families
- Each family further decomposes into 2–5 sub-categories with distinct transmission mechanisms
- Financial institutions must assess **all branches** – ignoring one creates a blind spot in the risk framework

This taxonomy evolved from Carney's 2015 speech through NGFS standardization.

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Four Transmission Channels

1. **Credit risk:** Increased probability of default (PD) and loss given default (LGD) as borrower revenues fall or collateral is damaged
2. **Market risk:** Repricing of securities, equities, and commodities as climate information is incorporated
3. **Operational risk:** Disruption to the bank's own operations, branches, data centres, and staff
4. **Liquidity risk:** Fire-sale dynamics when multiple institutions de-risk simultaneously; deposit flight from exposed regions

ASEAN Channel Examples

Channel	Example
Credit Market	Mekong rice farmer NPLs after drought Palm oil equity drop on EU deforestation regulation
Operational Liquidity	Bank branch flooded in Bangkok 2011 Mass withdrawal after typhoon in rural Philippines

Note

A single climate event can activate **multiple channels simultaneously**. Typhoon Haiyan triggered credit, operational, and liquidity risk in affected Philippine banks.

Every climate risk reaches the bank through one or more of these four channels.

Can You Trace the Chain From Typhoon to Bank Loss?

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General Transmission Formula

$$\begin{aligned} \text{Climate Event} &\xrightarrow{\text{real economy}} \Delta \text{Revenue}_i \\ \Delta \text{Revenue}_i &\xrightarrow{\text{credit}} \Delta \text{PD}_i \\ \Delta \text{PD}_i \times \text{EAD}_i \times \text{LGD}_i &= \text{Expected Loss}_i \\ \sum_i \text{EL}_i &\xrightarrow{\text{provisions}} \Delta \text{CAR} \end{aligned}$$

Where:

- PD = Probability of Default
- EAD = Exposure at Default
- LGD = Loss Given Default
- CAR = Capital Adequacy Ratio

Worked Example: Typhoon in Visayas

Parameter	Value
Agricultural exposure	PHP 50 billion
Crop loss from typhoon	15%
Pre-typhoon NPL ratio	3.0%
Post-typhoon NPL ratio	12.0%
LGD (damaged collateral)	65%
Additional provisions	PHP 2.9B
CAR impact	-0.8 pp

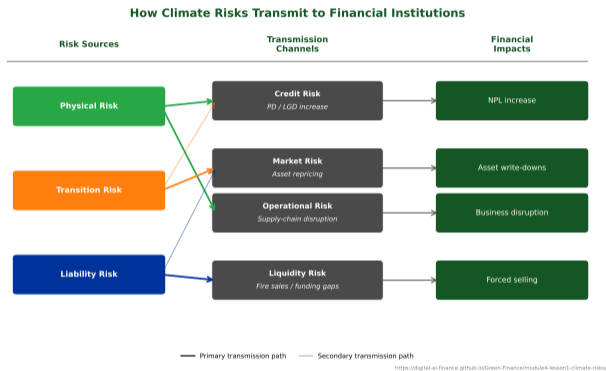
Result

A single typhoon erodes 0.8 percentage points of capital adequacy. For a bank near the 10% regulatory minimum, this can trigger supervisory intervention.

This is a simplified example. Real stress tests (Lesson 4.5) model thousands of loans simultaneously.

How Do All Transmission Channels Connect?

[INTERMEDIATE]



- Physical risks primarily drive **credit and operational risk** through direct damage and business disruption
- Transition risks primarily drive **market risk** through asset repricing and stranded asset write-downs

Physical risks primarily drive credit and operational risk; transition risks primarily drive market risk.

What Happens When Physical and Transition Risks Collide?

[INTERMEDIATE]

Compound Risk: Physical × Transition

Scenario: A Vietnamese cement factory in a flood-prone coastal zone.

- **Physical:** Factory flooded every 3–5 years; repair costs \$2M per event
- **Transition:** Carbon tax applied to cement production (\$15/tCO₂, rising)
- **Compound:** After the flood, reconstruction must use low-carbon materials (regulatory requirement), increasing costs by 35%

ASEAN Compound Risk Examples

- Thai auto parts factory: flood damage + EV transition renders combustion engine tooling obsolete
- Philippine coal plant: typhoon damage + energy transition makes rebuild uneconomic
- Indonesian palm oil: forest fire + EU deforestation regulation closes export market

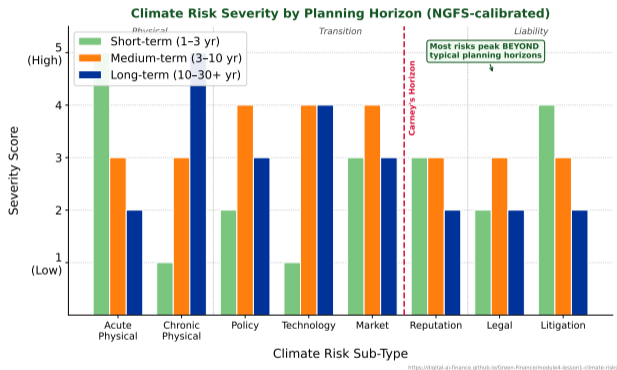
Key Insight

Compound risks are **non-additive**: the combined impact exceeds the sum of individual risks. A flooded factory that also faces carbon taxes may become permanently unviable, whereas either risk alone would be manageable.

Compound risks are non-additive: the combined impact exceeds the sum of individual risks.

When Do Different Climate Risks Bite?

[FOUNDATION]



- **Acute physical risks** can materialize tomorrow – but banks plan on 1–3 year cycles
- **Transition risks** peak in the medium term (2025–2035) as policies tighten and technologies disrupt
- **Chronic physical risks** are the “long tail” – sea-level rise and temperature shifts that reshape entire economies over 30–80 years

Carney's 'tragedy of the horizon': the most severe risks lie beyond typical planning horizons.

Who Is Most Exposed? Sectoral Risk Mapping

[INTERMEDIATE]

High-Exposure Sectors

- **Fossil fuels:** transition + stranded assets
- **Agriculture:** physical (drought, flood, heat)
- **Real estate:** physical (coastal, flood zones)
- **Transport:** transition (EV shift, fuel costs)
- **Cement/Steel:** transition (carbon-intensive)

Lower-Exposure Sectors

- **Technology:** low physical, low transition
- **Healthcare:** low direct exposure
- **Telecoms:** infrastructure risk only
- **Renewables:** transition *opportunity*
- **Financial services:** indirect via portfolio

Sector	Acute Phys.	Chronic Phys.	Transition	Liability
Fossil Fuels	Low	Low	Very High	Very High
Agriculture	Very High	Very High	Medium	Low
Real Estate	High	High	Medium	Medium
Transport	Medium	Low	High	Medium
Renewables	Medium	Low	Opportunity	Low

Sectoral exposure mapping is the first step in building a portfolio-level risk assessment.

What Does Financial Materiality Mean for Climate Risk?

[FOUNDATION]

Two Lenses of Materiality

Financial materiality (outside-in): How does climate change affect the *firm's value*? Revenue loss, asset impairment, increased costs.

Impact materiality (inside-out): How does the *firm's activity* affect climate? Emissions, deforestation, water use.

Double materiality = both lenses simultaneously. A coal plant is financially material (stranded asset risk) *and* impact material (CO₂ emissions).

Example: Coal Power Plant

Lens	Assessment
Financial	Asset stranding risk as carbon tax rises; re-financing cost increases
Impact	0.9 tCO ₂ /MWh; contributes to physical risk for others
Double	Both: creates risk <i>and</i> faces risk

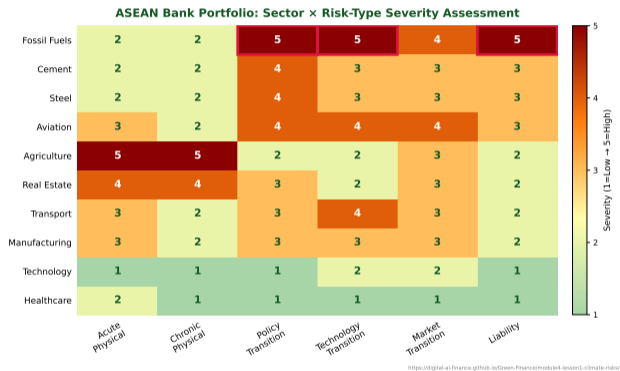
Key Insight

The EU approach (CSRD/ESRS) requires **double materiality**. The ISSB approach (IFRS S2) uses **single materiality** (financial only). ASEAN regulators are choosing between these frameworks now.

Double materiality is the EU approach (CSRD/ESRS). Single materiality (financial only) is the ISSB approach.

How Do You Build a Climate Risk Heatmap?

[INTERMEDIATE]



- Rows represent **sectors**; columns represent **risk sub-types**; colour intensity encodes severity
- Agriculture and fossil fuels show the highest overall exposure but through **different risk channels**
- **Extension:** Add a geography dimension for ASEAN country-level analysis – creating a 3D risk cube (sector × risk type × country)

Quantitative Lab: Students build this heatmap in Python using NGFS data + World Bank Climate Portal.

[INTERMEDIATE]

Four-Step Classification Process

1. **List sectors:** Identify the bank's top 10 sector exposures by outstanding loan volume
2. **Score risks:** Rate each sector on 6 risk sub-types (acute physical, chronic physical, policy, technology, market, liability) using a 1–5 scale
3. **Weight by exposure:** Multiply risk scores by the bank's % exposure to each sector
4. **Identify concentrations:** Flag the top-3 sector–risk combinations that drive the most portfolio risk

Example Output

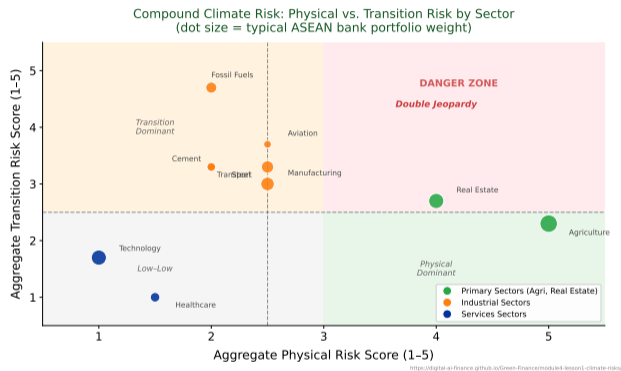
Sector	Exp.%	Score	Weighted
Agriculture	30%	4.5	1.35
Real Estate	25%	3.8	0.95
Energy (fossil)	10%	4.2	0.42
Manufacturing	15%	2.8	0.42
Services	20%	1.5	0.30

Advanced: Repeat this process per ASEAN country to build the full sector × geography × time horizon risk cube.

This worked example mirrors the Quantitative Lab exercise.

Where Do Physical and Transition Risks Concentrate?

[INTERMEDIATE]

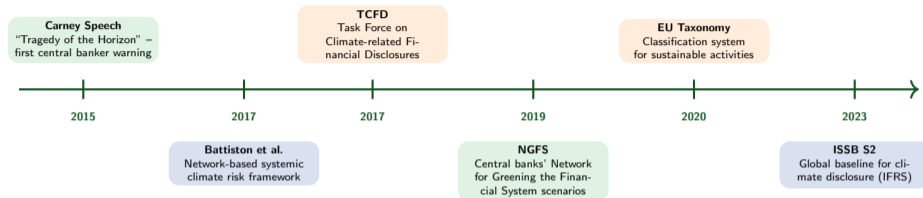


- The upper-right “**double jeopardy**” quadrant contains sectors exposed to *both* high physical and high transition risk – the most dangerous concentration
- Agriculture and fossil-dependent manufacturing cluster in this quadrant for ASEAN economies
- Sectors in the lower-left are relatively sheltered, but may still face **indirect exposure** through supply chain links

The ‘double jeopardy’ quadrant contains sectors exposed to **BOTH** physical and transition risk.

How Did the Climate Risk Taxonomy Evolve?

[PhD]



- Each iteration expanded scope: from **idiosyncratic risk** (Carney) to **systemic framework** (Battiston) to **regulatory standard** (EU Taxonomy, ISSB)
- ASEAN regulators are now adopting elements from each stage – Singapore leads with MAS guidelines aligned to TCFD/ISSB

The taxonomy is not static. Each iteration expanded the scope from idiosyncratic to systemic framing.

[PhD]

The Battiston et al. (2017) Argument

Climate risk is fundamentally **systemic**, not idiosyncratic:

- Financial institutions are connected through **interbank lending**, shared exposures, and derivatives
- A climate shock to one sector (e.g., fossil fuels) propagates through the **financial network**
- Even a “small” initial shock (<1% of assets) can trigger **cascading defaults**
- Standard diversification fails because climate shocks are **correlated across sectors**

Method: Network analysis of EU financial exposures to climate-sensitive sectors, showing amplification of up to $\times 3$ through second-round effects.

Implications for Risk Management

- **VaR fails:** Value-at-Risk assumes independent, normally distributed losses – climate risk violates both assumptions
- **Stress tests needed:** Scenario-based analysis (NGFS scenarios) replaces historical backtesting
- **Macroprudential:** Individual bank soundness is insufficient; regulators must assess **system-wide** exposure
- **Contagion channels:** Fire sales, counterparty defaults, and collateral repricing create feedback loops

For ASEAN

Battiston's framework is especially relevant for ASEAN where banking sectors are concentrated (3–5 large banks hold 60–80% of assets) and exposure to climate-sensitive sectors is high.

Battiston et al. (2017) showed that even small climate shocks can trigger large systemic losses.

[PhD]

Litigation as Market Discipline (+)

- Forces disclosure: firms that face litigation improve climate reporting (“litigation premium”)
- Creates price signals: markets discount sued firms, rewarding proactive disclosure
- Strengthens governance: D&O liability motivates board-level climate oversight
- Fills regulatory gaps: litigation acts where regulation is absent or slow

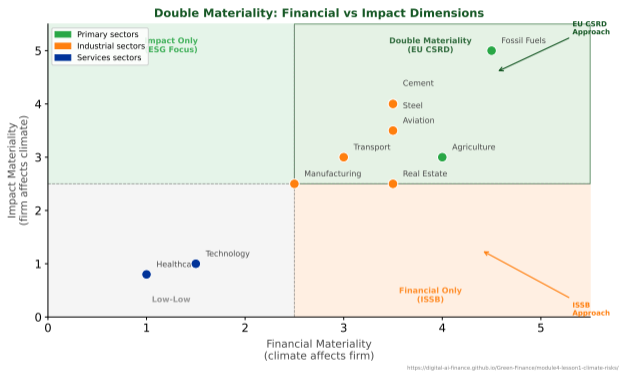
Data (Setzer & Higham, 2023): 2,500+ cases globally. 70% filed since 2015. 25% target governments, 75% target corporations. The Philippines Commission on Human Rights case against 47 carbon majors is the largest ASEAN proceeding.

Litigation as Systemic Risk (–)

- Uncertain liability: total contingent claims could reach **trillions**, far exceeding current provisions
- Insurance strain: liability insurers face correlated claims across multiple industries
- Chilling effect: fear of litigation may **discourage** voluntary disclosure (paradox)
- Jurisdictional fragmentation: inconsistent rulings across ASEAN create regulatory uncertainty

Climate litigation is the fastest-growing category of climate-related financial risk.

[FOUNDATION]



- The EU CSRD/ESRS framework requires assessment on **both axes**: how climate affects the firm (financial materiality) *and* how the firm affects climate (impact materiality)
- **Coal power** sits in the “Double Materiality” quadrant: it faces stranded asset risk *and* is a major emissions source
- This framework bridges **risk management** (Module 4) and **sustainability reporting** (Module 5)

Double materiality is the bridge between risk management (Module 4) and reporting (Module 5).

Case Study: Vietnam's Mekong Delta – A Bank's Nightmare?

[FOUNDATION]

The Setting

The Mekong Delta is Vietnam's "rice bowl" and the country's most climate-vulnerable region. A mid-sized Vietnamese commercial bank has significant exposure:

Parameter	Value
Share of Vietnam's rice	50%
Share of Vietnam's aquaculture	90%
Saltwater intrusion by 2050	40–50 km
Bank's agricultural exposure	30% of portfolio
Agricultural NPL (current)	2.5%

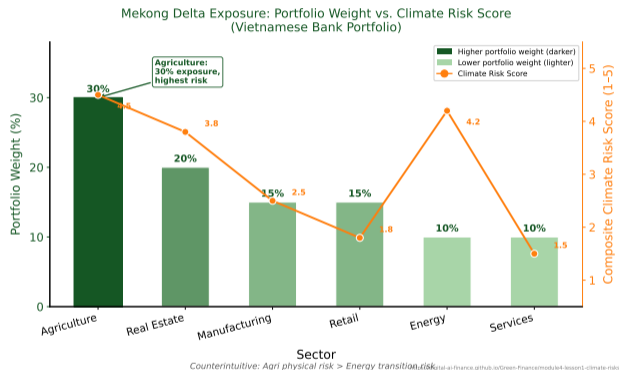
The Bank's Dilemma:

- Agriculture is the bank's most profitable segment (**highest margins, deepest client relationships**)
- But it is also the most exposed to **physical risk** (flooding, saltwater intrusion) and **transition risk** (water regulation, export standards)
- Withdrawing from the sector would devastate **rural communities** the bank serves

Task: Use the taxonomy from this lesson to classify every risk channel affecting this portfolio.

ASEAN Case Study: This is the capstone exercise for Lesson 4.1.

[FOUNDATION] [INTERMEDIATE]



- Agriculture **physical risk** dominates the Mekong Delta exposure profile – exceeding fossil fuel transition risk in absolute terms
- Chronic risks (saltwater intrusion, temperature rise) accumulate **gradually**, making them harder to detect in annual risk reviews
- The bank faces a **concentration risk**: 30% exposure to a single sector in a single geography amplifies all risk channels

Agriculture physical risk often exceeds fossil fuel transition risk in ASEAN banks.

[INTERMEDIATE]

Risk by Time Horizon

Horizon	Key Risks
Short (1–3yr)	Acute flooding events; seasonal drought; typhoon damage to crops
Medium (3–10yr)	Saltwater intrusion advancing inland; water regulation tightening; export standard changes (EU CBAM)
Long (10–30yr)	Permanent loss of arable land; sea-level rise; mass migration from delta; systemic food security crisis

Estimated PD Impact by Horizon

Horizon	PD Increase	Portfolio Loss
Short	+2–4 pp	PHP 1.0–2.0B
Medium	+5–8 pp	PHP 2.5–4.0B
Long	+10–20 pp	PHP 5.0–10.0B

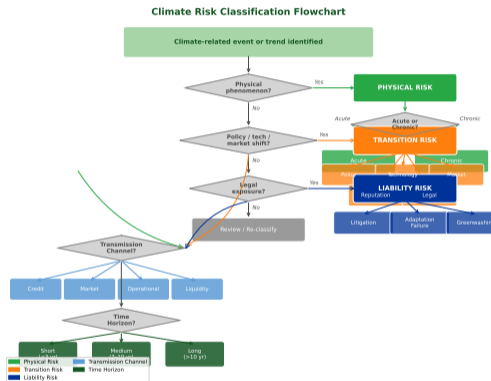
The Strategic Question

The bank cannot exit agriculture overnight. It must **manage the transition**: shift lending toward climate-resilient crops, require adaptation investment as loan conditions, and gradually reduce geographic concentration.

The three-horizon framework forces bankers to look beyond the next credit cycle.

How Do You Classify Any Climate Risk? A Decision Flowchart

[FOUNDATION]



Every risk event enters at the top and exits with a full (Type, Channel, Horizon) classification.
<https://simgala.com/source/gfba/carbon-footprintandrelated-climate-risk>

- Start with the **source**: Is the risk driven by a climate event (physical), a policy/market shift (transition), or a legal claim (liability)?
- Follow the branches to identify **sub-type**, **transmission channel**, and **time horizon**

This decision flowchart works for ANY financial institution.

[INTERMEDIATE]

Five Evaluation Questions

1. **Physical acute:** What % of collateral is in flood/typhoon zones?
Score: 4/5 – 35% coastal exposure
2. **Physical chronic:** What % of agricultural loans are in areas with projected yield decline >15%? *Score: 3/5 – 20% Mekong Delta*
3. **Transition policy:** What % of portfolio faces direct carbon pricing?
Score: 2/5 – 8% in carbon-taxed sectors
4. **Transition technology:** What % in sectors facing clean-tech disruption? *Score: 3/5 – 18% fossil + transport*
5. **Liability:** What % in sectors with active climate litigation? *Score: 2/5 – 5% fossil + cement*

Composite Score

Risk Type	Score	Weight	Weighted
Physical acute	4	0.30	1.20
Physical chronic	3	0.25	0.75
Transition policy	2	0.15	0.30
Transition tech	3	0.20	0.60
Liability	2	0.10	0.20
Composite			3.05 / 5

Top-3 Actions:

- Reduce coastal collateral concentration (physical acute)
- Require adaptation plans for Mekong Delta loans (chronic)
- Develop transition pathway for fossil-exposed clients (tech)

Students replicate this in Python and extend it to their own country.

[FOUNDATION]

Seven Key Concepts

1. Climate risk has **three families**: physical, transition, and liability
2. Physical risk splits into **acute** (events) and **chronic** (trends)
3. Risks reach banks through **four channels**: credit, market, operational, liquidity
4. Compound risks are **non-additive** – interaction effects dominate
5. **Time horizons** span from tomorrow to 2100
6. **Double materiality** captures both directions of impact
7. Classification is the **prerequisite** for measurement and management

Where This Leads

Lesson	Builds On
4.2	Frameworks (TCFD, TNFD) for <i>reporting</i> the risks classified here
4.3	<i>Measuring</i> these risks with ESG scoring and ratings
4.4	<i>Integrating</i> climate risk into portfolio construction
4.5	<i>Stress testing</i> under NGFS scenarios
4.6	<i>Pricing</i> climate risk into financial products

The Arc of Module 4

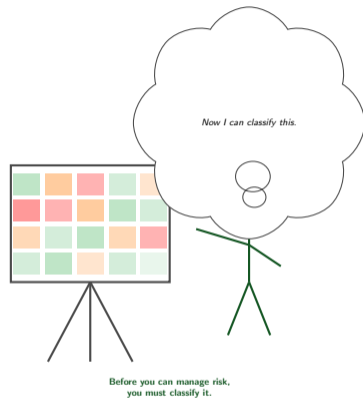
Classify (4.1) → Report (4.2) → Measure (4.3) → Integrate (4.4) → Stress Test (4.5) → Price (4.6)

Lesson 4.1 complete. Next: Lesson 4.2 – Climate and Nature Risk Frameworks (TCFD and TNFD).

The Pedagogical Arc

- We began with a banker overwhelmed by a typhoon's impact on the loan book – **no framework, no language**
- We end with the same banker equipped with a taxonomy, transmission channels, materiality lenses, and a decision flowchart

Remember: The taxonomy is not an end in itself. It is the **foundation** for everything that follows in Module 4 – from TCFD reporting to NGFS stress testing to climate-adjusted pricing.



Original illustration. The pedagogical arc: from 'What happened?' to 'How do I classify it?'

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All references are open-access or available through university libraries.