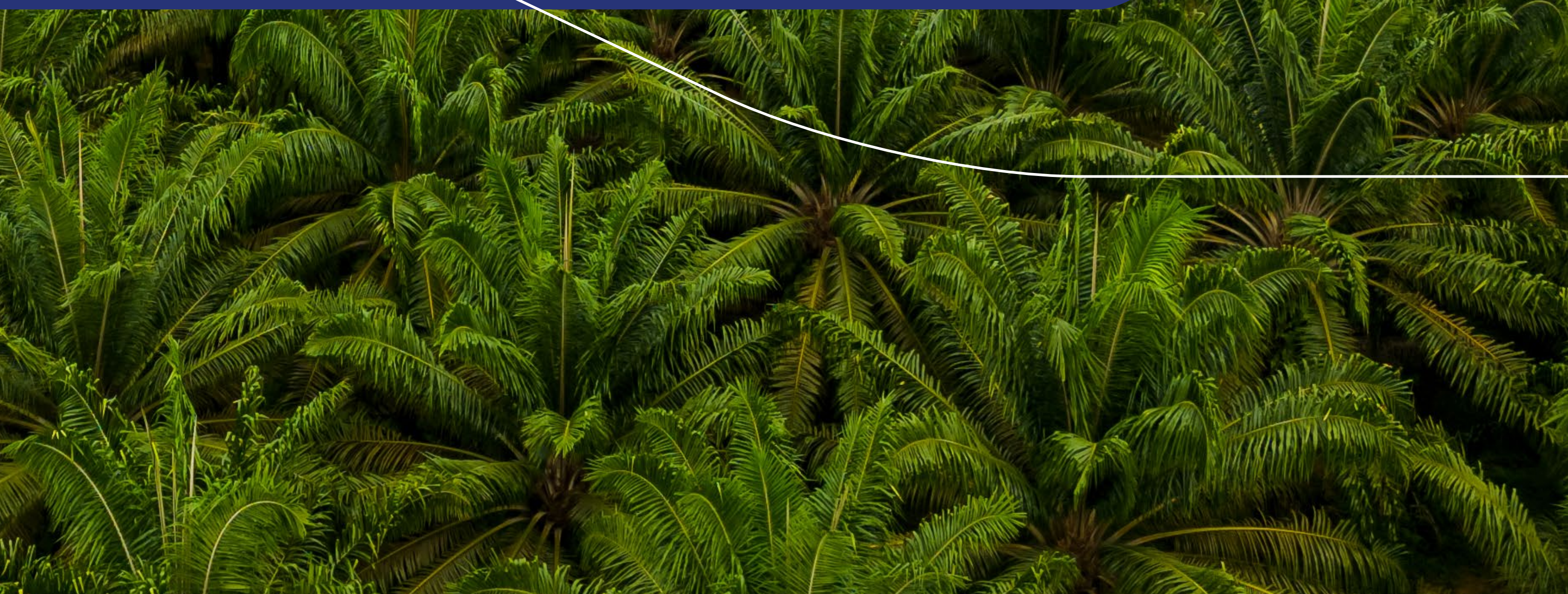
UNIVERSITY OF CAMBRIDGE | CISL Cambridge Institute for Sustainability Leadership

Building Capacity to Identify and Assess Nature-Related Financial Risks

June 2025



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This project is a collaboration across CISL, DBS, OCBC and UOB whereby the banks lead the risk assessment process and CISL provides the scenario construction and data parameters as well as leading the writing of the report. Figures used in this publication are rounded to two decimal places, where relevant.

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Preface

To support broader industry awareness, identification and assessment of nature-related financial risks in Asia, the University of Cambridge Institute for Sustainability Leadership (CISL), with the support of the Monetary Authority of Singapore (MAS), collaborated with three Singapore banks on the project 'Building Capacity to Identify and Assess Nature-Related Financial Risks'.

The project's objective is to develop the banks' internal capabilities to:

(i) Build capacity to recognise and evaluate nature-related dependencies and potential financial impacts in their wholesale lending portfolios by a high-level mapping of nature dependencies.

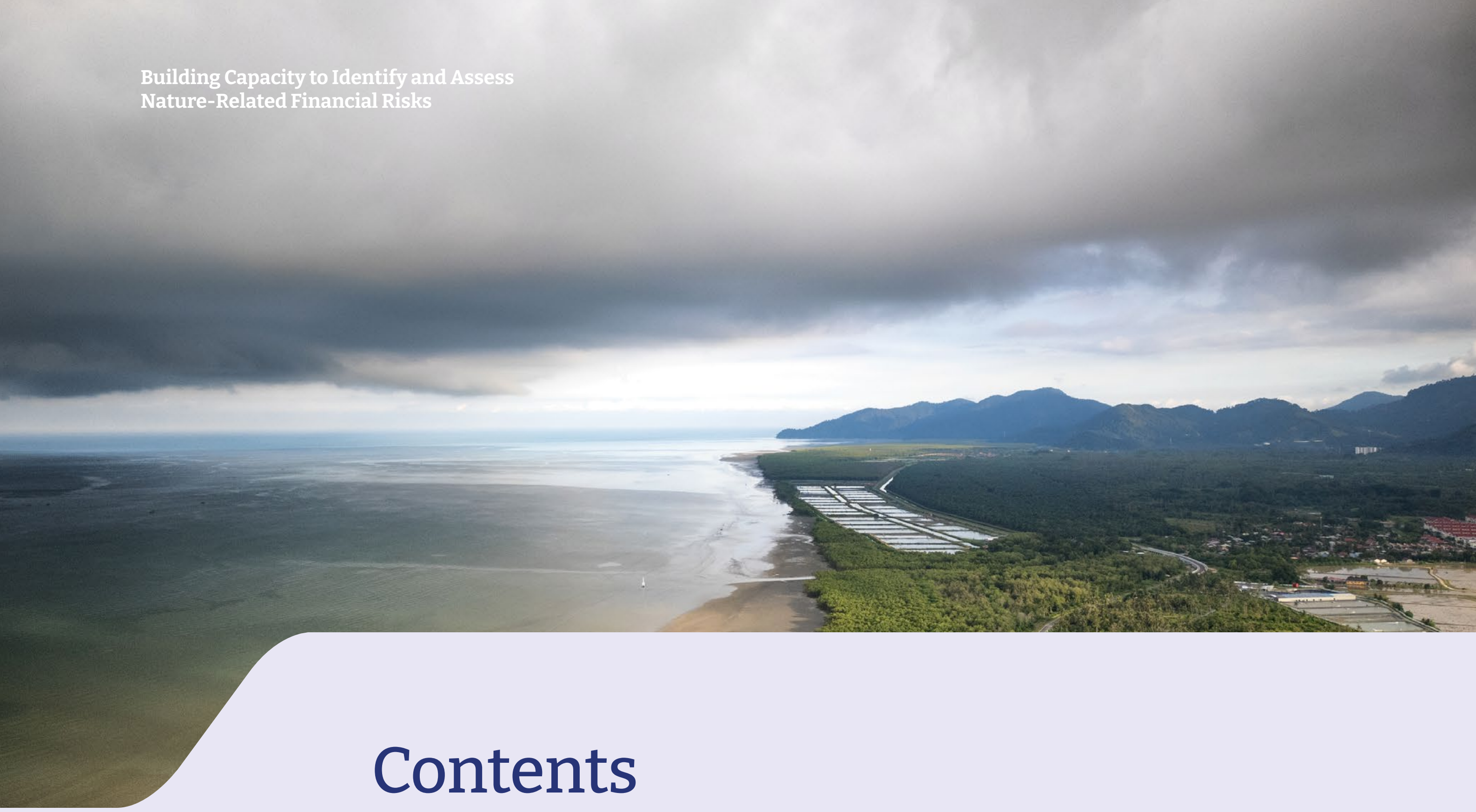
(ii) Develop an exploratory, sector-specific scenario use case as an archetype for understanding and assessing potential business impacts linked to nature-related risks. The purpose of this use case is to encourage and accelerate further assessments of nature-related risks across the financial sector.

We conducted this project across two stages. In the first stage, we categorised various industries and sub-industries using the ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure) tool materiality ratings, overlaid with each bank's lending portfolio data. This analysis highlighted portfolios with relatively higher dependencies on nature and ecosystem services for their operational and financial health. The consolidated results from the three banks' portfolios then identified five industries, from which agricultural production was selected for an in-depth use case in the project's second stage.

Within agricultural production, palm oil production was chosen due to its importance in Southeast Asia, data maturity, reliance on international production chains, and global awareness of its potential nature-related dependencies. This was further supplemented with an integrated climate–nature scenario development where El Niño was chosen as an anchor event, within which nature loss is nested and analysed. This paper focuses on the second stage described, outlining the scenario explored and potential financial impacts on selected companies.

We recognise that nature-related risk assessment is still very nascent, and this exploratory use case only provides an early indication of the direction of travel, with several areas identified for further study. It also reveals current knowledge gaps and limitations that need to be addressed before a comprehensive analysis can be conducted as part of risk assessments.

The creation of this use case has supported financial institutions in their engagements on risks arising from nature loss. Collective efforts from all parties in the ecosystem, including financial institutions, real economy players and policymakers, are necessary to achieve positive change.



Contents

Executive summary

To meet the overall objective of developing the banks' internal capabilities to:

(i) Recognise and evaluate nature-related dependencies.

(ii) Assess potential financial and business impacts on the banks' credit lending portfolios linked to nature-related risks. The project's second stage, through an exploratory scenario analysis approach, assessed how nature-related risk events can potentially impact the credit ratings of companies in the palm oil industry in Indonesia and Malaysia.

The scenario featured the palm oil industry in Indonesia and Malaysia, locations that collectively account for the majority of global palm oil production. Understanding the industry's vulnerability to nature-related risk events is crucial due to growing demand for palm oil and the increasing frequency and intensity of nature-related risk events.

To assess the impact of probable nature loss events (linked to physical risks) on the financial vulnerability of companies in the palm oil supply chain, climate–nature loss scenarios were developed. Given that nature is highly location-specific, country-specific scenarios are essential. This use case focuses on hypothetical scenarios of nature loss in Indonesia and Malaysia, triggered by an intensified El Niño climate phenomenon, impacting ecosystem services critical to the palm oil industry. The analysis was extended to examine the resulting financial implications for the banks' credit lending portfolios. The scenarios created are climate–nature loss scenarios, designed to answer the question:

> "What would be the potential implications on banks' lending portfolios to the palm oil industry in Indonesia and Malaysia under a severe and disruptive climate–nature loss scenario?"

Broadly, the analysis of 16 samples showed that upstream players, compared to integrated players, were more sensitive to the impact of nature-related risks. Companies with relatively better financial strength were also more resilient to the short-term acute stress. Overall, the impact on companies was limited, especially for a mild scenario, although for certain companies in a more severe scenario, the impact was elevated. Further assessment is needed in order to evaluate the portfolio-level impact.

This scenario analysis emphasises the importance of understanding nature-related dependencies as a potential risk factor in the credit risk analysis, and the complexities of the transmission mechanism of nature loss events to the financial strength of companies. We recognise that nature-related risk assessment is still very nascent and while the scenario offers preliminary insights into potential impacts, it does not fully capture the complex interactions between climate and nature risks and the complexity of transmission mechanisms involved. If society continues to erode nature, impacting the nature-based services on which all businesses depend, considering those dependencies and risks will become increasingly important.

This paper is comprised of four main sections:

SECTION 1
Industry context

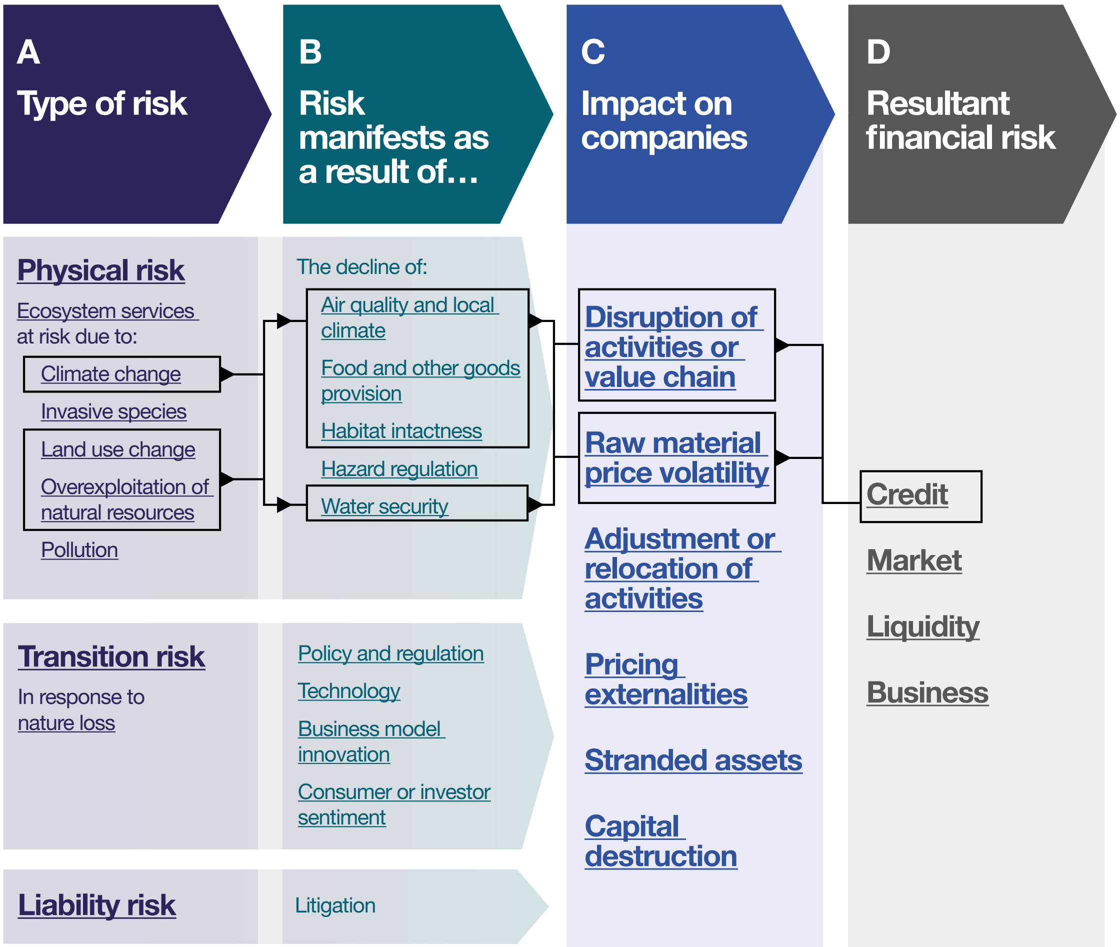
SECTION 2
Probable nature loss events scenario

SECTION 3
Business impacts

SECTION 4
Potential credit risk impacts

These sections follow the framework for identifying nature-related financial risks (Figure 1).

Figure 1: Framework for identifying and assessing nature-related financial risks, CISL 2021



SECTION 1

Industry context

The palm oil industry is a major global sector. It is concentrated in Southeast Asia, primarily in Indonesia and Malaysia, which together account for over 85 per cent of the world's palm oil production (European Palm Oil Alliance 2024).

There are three main outputs from oil palm trees:

Crude palm oil (CPO)

Extracted from the flesh of the fruit (the mesocarp).

Palm kernel oil

Extracted from the seed or kernel of the fruit.

Fractionated palm oil

Palm oil is often fractionated into solid (stearin) and liquid (olein) components to create more specific products for food and industry.

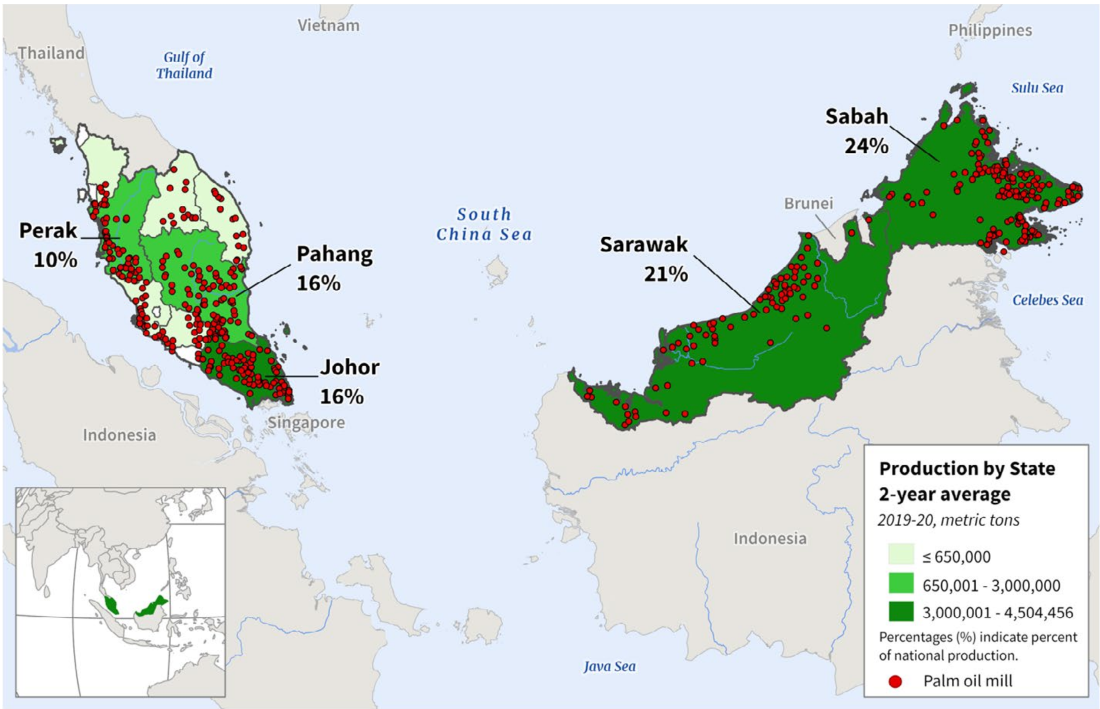
For the purposes of this use case, we will examine specifically how nature risk events impact the ability to produce CPO, which is highly dependent on ecosystem services including soil quality regulation services and pollination services. CPO is a highly versatile and widely used vegetable oil found in numerous products including food, cosmetics and biofuels. Globally, palm oil supplies 40 per cent of the world's vegetable oil demand (Voora et al. 2023). CPO's high yield and relatively low production cost compared to other edible oils make it an attractive crop for large producers.

Further, millions of smallholder farmers in Southeast Asia have transitioned over the past decades from cultivating rubber to palm oil to supply the more lucrative and diversified palm oil market (Shaw, Jai-In, and Juntopas 2018). This is likely because palm oil (the plant in full) yields are 11 times higher than those of soybeans, ten times higher than sunflower, and seven times higher than canola per hectare (as of 2015) (WWF and Conservation International 2015).

Despite the creation in recent years of synthetic alternatives to palm oil, there is currently no single substitute that can replace CPO for all its uses at the price point of its production (Shaw, Jai-In, and Juntopas 2018; Voora et al. 2023). As illustrated in the following two maps in Figure 2 (Foreign Agricultural Service 2024), the primary regions of palm oil production in Indonesia are Sumatra and Kalimantan, and in Malaysia, the Peninsula, and East Malaysia states of Sabah and Sarawak (Murphy, Goggin, and Paterson 2021).

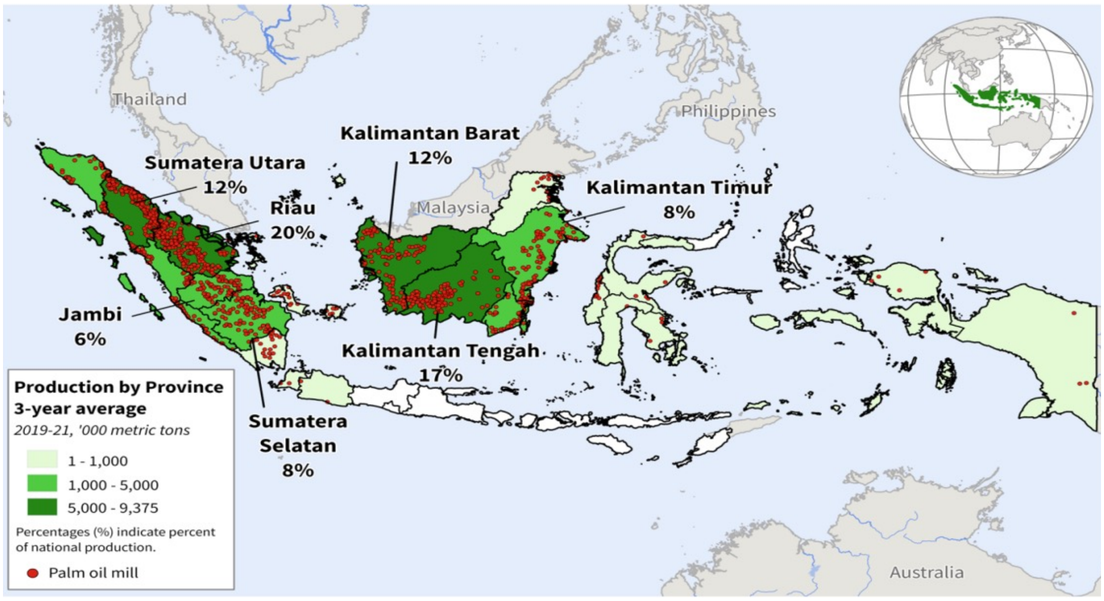
Figure 2: USDA, Foreign Agriculture Service
https://ipad.fas.usda.gov/countrysummary/default.aspx?id=MY&crop=Palm%20Oil
based on Malaysian Palm Oil Board Statistics and Global Forest Watch Palm Oil Mills

Palm Oil Production in Malaysia



USDA, Foreign Agriculture Service 2023
https://ipad.fas.usda.gov/highlights/2023/11/Indonesia/index.pdf
based on Badan Pusat Statistik Indonesia 2021

Palm Oil Production in Indonesia



In terms of annual production, the global palm oil industry is worth about US$ 60 billion, employing six million people directly (almost five million of these are in Indonesia and Malaysia (Voora et al. 2023)), plus an additional 11 million indirectly (Kadandale, Marten, and Smith 2019). In 2023, 77.28 million metric tonnes (Mt) of CPO were produced (Foreign Agricultural Service U.S. Department of Agriculture 2024), see Table 1 for regional production figures.

Annual palm oil production is expected to grow to 93–156 million Mt by 2050 (Murphy, Goggin, and Paterson 2021). With Indonesia and Malaysia collectively producing 85 per cent of the global supply, we expect that these two countries will produce 80–132 million Mt by 2050 (Carter et al. 2007; Ayompe, Schaafsma, and Egoh 2021) (assuming they continue to hold 85 per cent of global production, and the environmental conditions allow for this growth trajectory). Many planters are smallholders, accounting for an estimated 40.8 per cent of the total Indonesian oil palm (Jelsma et al. 2017); hence a nature loss event could have a disproportionate impact due to lack of resources and organisational capacity to mitigate impact associated with nature loss.

The global palm oil industry is worth about **US$60 billion**.

The industry directly employs **6 million people**.

Table 1: CPO production figures (historical empirical data unless stated forecast), million Mt (metric tonnes).

Source	2020	2021	2022	2023	2024 (Forecast)	Average 5-year rolling
MPOB (Malaysian Palm Oil Board)	19.14	18.12	18.45	18.55	18.75	18.60
GAPKI/ IPOA (Indonesian Palm Oil Association)	47.03	46.89	46.73	53.2	54.4	49.65

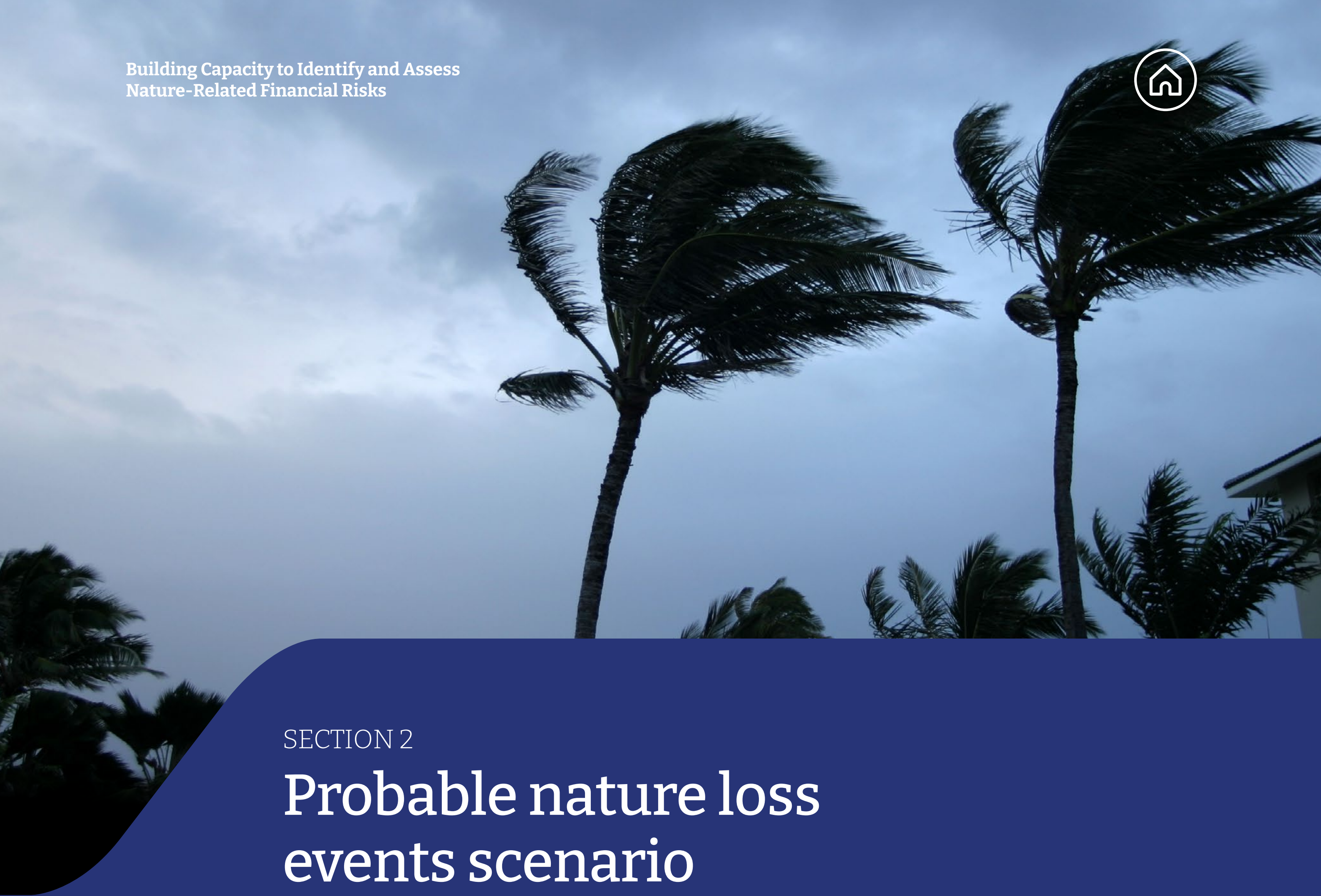
Figure 3: CPO Historical Price, price in Malaysian Ringgit. Retrieved on 19 November 2024 from Trading Economics, with edits to show major El Niño and La Nina events.

1.1 Critical ecosystem services

Building on this context, we focus this use case on the palm oil industry, specifically production of CPO. To do this we must first understand the ecosystem services that underpin the business. Based on ENCORE data – global industry averages (ENCORE Partners, 2024) – 89 per cent of the ecosystem services in the agricultural product industry have a medium or high level of materiality in relation to their nature dependency (ENCORE Partners, 2024).

This means that 89 per cent of the ecosystem services required for agricultural products (small and large-scale irrigated arable crops) play a significant role in ensuring the continued production of agricultural products and could lead to significant negative financial repercussions if those ecosystem services were lost.

These ecosystem services include (note list not exhaustive): soil quality regulation services, global climate regulation, rainfall pattern regulation and pollination services *((please see ENCORE at encorenature.org for more information on these ecosystem services)*.



SECTION 2

Probable nature loss events scenario

To investigate the economic impact on CPO due to compromised ecosystem services in Indonesia and Malaysia, we must first understand likely threats to those ecosystem services.

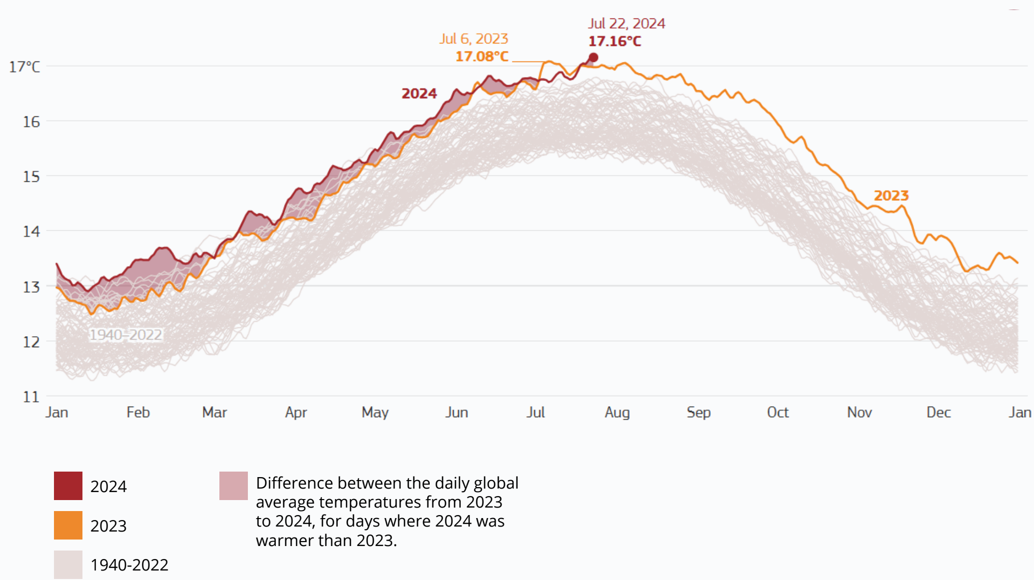
2.1 Nature risks associated with CPO production

Nature loss is a major source of risk, with climate change potentially exacerbating this as a driver of nature loss. Working together this may potentially amplify the risks associated with CPO production. Climate change, a source of global nature-related risk, is negatively impacting the suitability of land to sustain productive crops, through water and heat stress. Nature loss, specifically ecosystem service degradation due to soil quality degradation and pollination disruption, is negatively impacting the ability of ecosystems to aid in sustaining productive crops.

2.1.1 El Niño–Southern Oscillation climate impact

On 22 July 2024, Earth experienced its warmest day since records began the 1940s, shortly after 2023 had been declared the hottest year on record (Figure 4). This has largely been driven by increased greenhouse gases, namely carbon dioxide and methane, being released into the atmosphere from human activities, with severe implications.

Figure 4: Daily global average surface air temperature

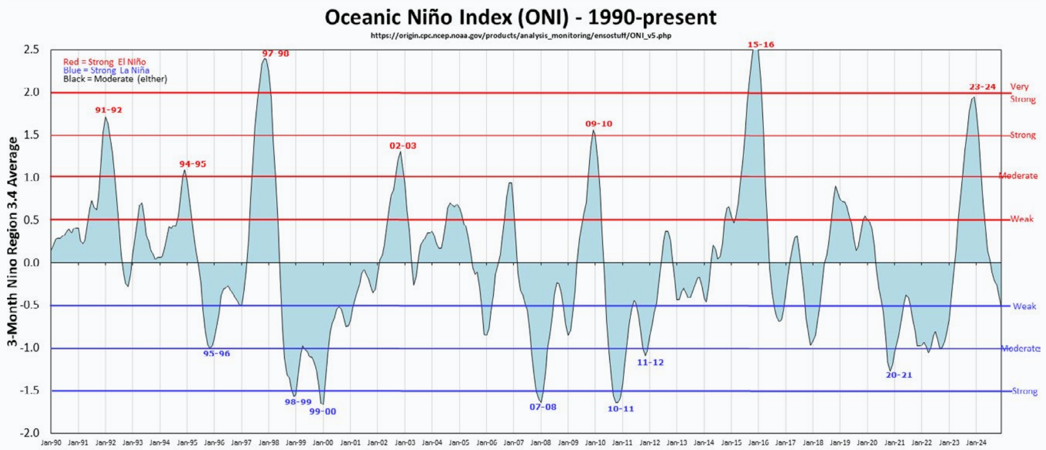


Data source: ERA5, via Climate Pulse.
Credit: C3S/ECMWF. (Copernicus and European Commission 2024)

Pertinent to Southeast Asia, including Indonesia and Malaysia, is how these increased temperatures are influencing the El Niño–Southern Oscillation (ENSO). ENSO is a naturally occurring system, composed of a pendulum of two extremes and driven by changes to the sea-surface temperature in the tropical Pacific Ocean. On one end of the pendulum is La Niña, which typically brings wet, cooler conditions, and on the other is El Niño, which typically results in drier, hotter conditions (Cai and Santoso 2023). A neutral state does exist between the two extremes. Occurrences of El Niño and La Niña can last between nine months and approximately a year and half. Although irregular in frequency, they are becoming more frequent and severe and now repeat every two to seven years (National Ocean Service 2024). As demonstrated in the figure below, some of the most severe El Niño years are 1997–98, 2014–16 and, most recently, 2023–24. The departure of these severe events from more regular El Niño events is an average increase of ≥ 2 degrees Celsius.

El Niño and La Niña can last between **nine months and approximately a year and half**.

Figure 5: El Niño and La Niña years and intensities;
Golden Gate Weather Services (Null 2024)



Since 1960, El Niño and La Niña events have become both more frequent and intense. In 2023, scientists confirmed that this was induced through anthropogenic influence (Cai *et al*. 2023) and modelling has shown that ENSO events have intensified by 10 per cent today from pre-1960 levels (Cai *et al*. 2023). Deemed one of the most important climate phenomena on Earth, increased intensity and frequency of ENSO will have significant impacts on weather, water through both drought and flooding, wildfires, ecosystems, economies, and social health and well-being (National Ocean Service 2024).

2.1.2 Ecosystem degradation

In this context, plus the scoping exercise using ENCORE described in section 1.1, below we focus on two key ecosystem services – soil quality regulation and pollination services – required for the continued production of CPO.

2.1.2.1 Soil quality regulation

The regulation of soil quality and the process of soil degradation consists of biological, chemical and physical degradation. Currently, about 33 per cent of world soils are moderately to highly degraded (United Nations Office for Disaster Risk Reduction 2020). When soil becomes degraded, it reduces the capacity of the soil to provide the nutrients and hospitability for crops to grow at the rate and size expected. This is particularly relevant for CPO production, which is currently a high-yield, low-production cost crop, in Indonesia and Malaysia. Economically, soil is very valuable. It is estimated that the total value of ecosystem services provided by soils is US$ 11.4 trillion annually (McBratney, Morgan, and Jarrett 2017). However, agricultural, industrial and commercial pollution; loss of arable land due to urban expansion, deforestation, overgrazing and unsustainable agricultural practices; and long-term climatic changes are all contributing to soil degradation.

2.1.2.2 Pollination services

Pollination is a crucial ecosystem service that supports biodiversity and ensures food security by enabling the reproduction of many plants, including those that produce fruit, vegetables and other crops. Globally, pollinators directly affect the yield/quality of 75 per cent of globally important crops. This is estimated to contribute US$ 235–577 billion per year (Potts *et al*. 2016; Khalifa et al. 2021). However, pollination is increasingly compromised by factors such as habitat loss, pesticide use, climate change and the decline in pollinator populations, including bees, butterflies and birds. Deforestation and urbanisation reduce the natural habitats that pollinators rely on (Ulyshen et al. 2023), while pesticide exposure harms their health and reproductive capabilities (Sponsler *et al*. 2019). Climate change further disrupts the timing of pollination and the availability of food for pollinators. As a result, the decline in pollinator numbers poses a significant threat to food production, economic stability and ecological balance, as pollination is crucial for fertilisation and subsequent fruit development in palm oil production.

33 per cent
of the world's soils are moderately to highly degraded.

75 per cent
of globally important crop yields are directly affected by pollinators.

2.2 Interconnection of climate change and nature loss

For this use case, we will examine how an intensified El Niño, leading to water and heat stresses, and the nature loss impacts of soil degradation and pollination disruption, impact the production of CPO. However, we cannot simply look at the damage of each environmental risk in isolation as they are deeply interconnected and mutually reinforcing.

Climate and nature risks are deeply intertwined. Changes in climatic patterns can exacerbate ecosystems and biodiversity loss, while nature plays a crucial role in regulating the climate through carbon sequestration. This climate–nature nexus is elaborated in the joint Intergovernmental Panel on Climate Change (IPCC)–Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) report on Biodiversity and Climate Change (Ruckelshaus et al. 2020) and the Taskforce on Nature-related Financial Disclosures (TNFD) recommendations (TNFD 2023). While risks associated with climate and nature loss are often currently addressed in largely siloed manners, there is recognition at an international level (Convention on Biological Diversity 2023) that the only way to fully achieve the goals of the Paris Agreement or the targets of the Kunming-Montreal Global Biodiversity Framework is to address climate change and nature loss together in a synergistic and holistic manner.

To neglect this interconnection would lead to unintended trade-offs and under-estimation of the true risk (Kedward, Ryan-Collins, and Chenet 2023). The past alone is not reflective of future trajectories. We need to pair historical insights with forward-thinking models and exploration. Future disasters could be much worse because of our increasingly complex and interconnected societies, the changing climate, and the growing pressure human activities put on natural systems (Kedward, Ryan-Collins, and Chenet 2023). To address this point, we explore the evidence and forecasted risks of El Niño and ecosystem degradation on CPO production separately, as most research to date focuses on one of the two risks but not the impact of one on the other. We then acknowledge the mutual reinforcement these risks could have on one another by proposing a mild and a severe scenario, taking into consideration the impact of warmer and drier temperatures arising from El Niño, and the impact of ecosystem degradation, namely, soil degradation and pollination disruption, on CPO production.

2.3 Evidence of nature loss impact and impact on CPO

There are several studies we can draw from to see how an intensified El Niño alongside ecosystem degradation could influence the production of CPO. We have included in the appendix, summary tables of the research studies used in this paper. These tables include the source, scope of the study and the negative or positive impact on CPO production from two perspectives, evidenced from historic events with empirical data (Appendix A – Table 9) and projections of estimated future impacts (Appendix A – Table 10).

2.4 Plausible nature loss scenario impacts to CPO

In this use case, we examine how an intensified El Niño, combined with ecosystem degradation, impacts the production of CPO in Indonesia and Malaysia. To create a plausible nature loss scenario, it is essential to consider the interconnection between El Niño impacts and weakened ecosystem services, which collectively have a negative effect on CPO production.

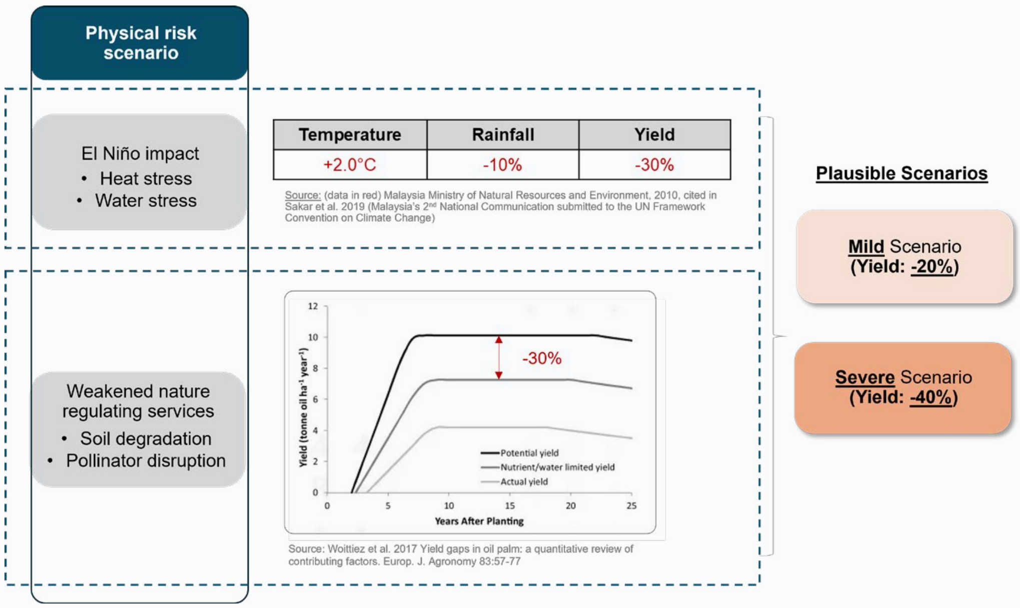
The evidence given in Table 9 and Table 10 in Appendix A demonstrates an overall negative impact on production volume from these environmental risks, ranging from -2 per cent to -40 per cent in isolated assessments of each risk. However, non-linearities and complexities relating to climate change and nature loss are often unaccounted for in much of the existing literature on environmental impacts to palm oil production. To address this gap while leveraging the evidence in Table 9 and Table 10, which illustrates the plausible range based on historical empirical data, we assume two scenarios – mild and severe – projecting their potential effects on production follows on the next page:

Table 2: Summary of scenarios assessed in this study

Source	Average 5-year rolling (2020–24)	Mild nature loss scenario (-20% production volume)	Severe nature loss scenario (-40% production volume)
MPOB (Malaysian Palm Oil Board)	18.60 million Mt	14.88 million Mt	11.16 million Mt
GAPKI/ IPOA (Indonesian Palm Oil Association)	49.65 million Mt	39.72 million Mt	11.16 million Mt

Using the average production levels from 2020 to 2024 in Indonesia and Malaysia and applying a probable nature risk or stress event, the industry could see a production reduction of 20 per cent in a mild scenario and 40 per cent in a severe scenario. These scenarios both envisage a one-year short-term acute impact on production volume, during which strategic management actions are not initiated, affecting companies' profitability and cash flows. It should be recognised that these are plausible scenarios, not predictions of future realities. That said, these proxy measures are rigorous, backed by historical empirical and forecast data (see example in Figure 6).

Figure 6: Plausible nature risk scenarios, figure adapted from Sakar et al. 2019 and Woittiez et al. 2017



SECTION 3

Business impacts

3.1 Supply chain and scope of business impact

Companies across the CPO value chain in Indonesia and Malaysia would be influenced by an intensified El Niño, in combination with ecosystem degradation. Based on Pacheco et al. (2017), we can broadly categorise the agricultural value chain for CPO as pre-production, producers, processors and retailers. For this use case, we look closely at the upstream value chain as noted in the table below. These companies consist of the plantations, where the harvest of fresh fruit bunches (FFB) is most likely to be directly impacted by the nature loss scenarios, and the millers. The proposed scenario may also impact processors and traders, and retail companies, which is an opportunity for further research following on from this study. For integrated players, we identified and applied the impact to the part of the business attributable to their palm oil upstream value chain.

Table 3: Overview of palm oil value chain

Upstream	Midstream	Downstream
Producers	Processors and traders	Retailers
- Plantation - Plantation and miller	- Standalone miller - Refiners - Transporters	- Direct food and consumer goods sales - Food services - Wholesale

3.2 Impact on producers/integrated players

There are several ways a producer of CPO could be impacted by a reduction in yield as articulated in the two scenarios: -20 per cent and -40 per cent. For example, a reduction in supply and production volume could lead to increased prices. Additionally, companies often need to bear increased production costs to cope with a challenged environment (for example due to an increased need for fertilisers or irrigation).

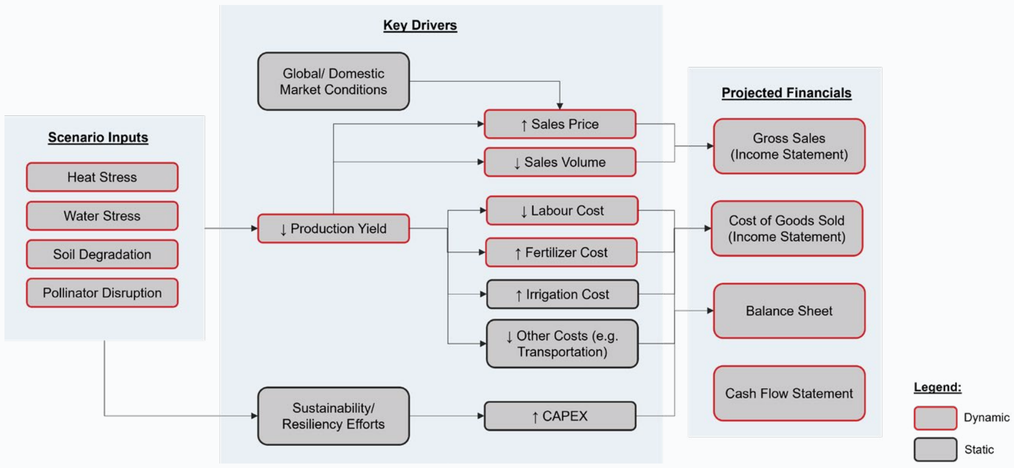
3.2.1 Variables for scenario analysis

For this scenario analysis, there are a number of variables that can be considered. We have categorised relevant variables, noting which will be treated as static or dynamic for the purposes of this analysis.

Dynamic variables *Included in business implications analysis*	**Static variables** *Assumed to remain constant in business implications analysis*
• **Sales volume** • **Average selling price** • **Fertiliser costs** • **Labour costs**	**Tax implications.** Given the inherent complexity of identifying a dynamic approach, we maintain each company's tax rate.
	Global market dynamics. It is noted that market dynamics are subject to change and may be impacted by a broad range of factors. As we have isolated the average selling price as a dynamic market factor, other market factors are to remain static.
	Management actions. Actions including mitigation and adaptation efforts and strategic business decisions, so as to identify impact on firms, in the absence of recourse measures.
	Dividend payout ratio. Ratio to remain constant unless the company becomes lossmaking, in which case dividend payout would cease.
	Capital expenditure. CAPEX growth assumed to remain constant, in line with the short-term timescales of the scenarios.
	Fixed asset values, trees in particular. Given the short-term project scope and lack of granular evidence in relation to tree mortality, we did not factor in losses to fixed asset valuations.
	Other variables. Given the lack of evidential data to calculate appropriate dynamic figures, these are assumed static.

We examine the four key dynamic variables likely to have a significant impact on the production of CPO within the one-year time horizon, though, as noted above, there are additional effects that exist beyond the scope of this analysis. Figure 7 below provides a summary of the transmission mechanism of the one-year acute scenario.

Figure 7: Transmission mechanism of one-year acute scenario



This is supported by a summary table of the business implications of the four key dynamic variables, across the two nature loss scenarios: mild and severe.

Table 4: Summary table of business implications (evidence and explanations noted below)

Business implication factor	Mild nature loss scenario (-20% volume)	Severe nature loss scenario (-40% volume)
Reduced supply and increased prices		
Sales volume	-20%	-40%
Average selling price	+31%	+62%
Increased production costs		
Fertiliser costs	+40%	+40%
Labour costs	-12%	-24%

The potential business implications across the two scenarios are explained in more detail on the next page.

3.2.1.1 Reduced supply and increased prices

Similar to other commodities, prices of CPO are heavily influenced by market supply and demand. Significant yield losses from El Niño events have historically led to increased prices up to around 20 per cent (see Table 11 in the Appendix). Information gathered as background research (see Table 9 in Appendix) indicates that this relationship of price and production volume changes during El Niño years, with prices increasing within the range of 0.9 per cent to 2.2 per cent for each 1 per cent reduction in production volume. For this scenario analysis, we will take the median figure of 1.55 per cent price increase per 1 per cent production volume decrease, acknowledging more technical pricing elasticity analysis sits outside the scope of this use case. Using this median figure, a yield loss of 20 per cent would result in a 31 per cent price increase and 40 per cent yield loss would result in a 62 per cent price increase.

In reality, the effect of price is multi-dimensional. It is possible that as yield declines towards 40 per cent, and price correspondingly increases, the market will respond with decreased demand. As such, there is a market cap on the extent of price increase in the case of a severe scenario. While wider market conditions also influence CPO prices, such as the supply and demand dynamics of other edible oils, this market dynamic is not covered in the scope of this study.

3.2.1.2 Increased production costs

Fertiliser can account for up to 60 per cent of the production cost for high-yielding plantations for smallholders (Brum Mauro et al. 2021), and reducing this input by half can reduce yields by up to 40 per cent (Ghazoul 2015). It plays an important role in mitigating yield reduction risks imposed by extreme levels of ENSO measures (Chu and Das 2020). This need could also be enlarged by an imbalance in the broader market. Fertiliser utilisation cost is likely to increase due to increased energy prices, climatic variation or geopolitical instability. However, this would manifest differently for different types of fertilisers, and for different producers (such as ‘standalone producers’ that are both planters and millers and ‘integrated players’ that are planters, millers and refiners). In the absence of data on fertiliser utilisation rates during ENSO events, we took a simple approach of estimating fertiliser utilisation cost through the proxy measure of fertiliser price increase (see Table 5).

Meanwhile, labour is needed for harvesting. With the reduction in FFB harvested, the labour cost is expected to decrease. Informed by literature findings (see Table 5), the negative impact on labour is estimated at 12 per cent for the 20 per cent yield loss scenario, and 24 per cent for the 40 per cent yield loss scenario.

El Niño events have historically led to increased prices up to around **20 per cent**

Table 5: Assumptions for increased production costs

Assumptions	Scenario 1 yield loss of 20%	Scenario 2 yield loss of 40%	Remarks
Fertiliser utilisation cost increase	40%	40%	"Impact of increases in fertilizer prices on long-term economic viability of palm oil production." Simeh, Mohd. Arif. 2010. Historic average after strong La Niña years register, US National Weather Service
Labour costs reduction due to reduced harvesting needs	12%	24%	"Trend in the Development of Oil Palm Fruit Harvesting Technologies in Malaysia." Sowat, Sharence. Nai., Ismail, Wan. Ishak. Wan., Mahadi, Muhammad. Razif., and Bejo, Siti. Khairunniza., and Kassim, Muhammad. Saufi. Mohd, 2018.

3.2.2 Resulting financial implications

In line with the transmission mechanisms identified in Figure 7, below is a summary of the projected financial implications of the two scenarios.

a. Income statement

For the income statement, combinations of declining yields, rising production costs, and an increased selling price in the aftermath of El Niño events are relevant. The table below (Table 6) represents the income statement line items which were projected during the credit risk impact analysis.

Table 6: Impact statement line items projected during the credit risk impact analysis

Income statement line item	Mild scenario	Severe scenario
Revenue	Base revenue x 105%	Base revenue x 97%
Cost of Goods Sold [1]	[0.4 Base COGS x 88%] + [0.4 Base COGS x 140%] + 0.2 Base COGS	[0.4 Base COGS x 76%] + [0.4 Base COGS x 140%] + 0.2 Base COGS

1 Cost of Goods Sold breakdown for palm oil producers is estimated at labour (40%), fertiliser (40%), other costs (eg transportation) (20%) evidenced by publicly available financial data of palm oil companies and informed by sectoral experience.

b. Balance sheet

Significant and prolonged nature loss events may potentially damage the balance sheets of palm oil companies, which may lead to companies having to take on additional debt to cover the additional costs, leading to higher interest costs.

For this scenario:

- We have assumed that the impact to the balance sheet is a reduction to retained earnings.
- Cash on the balance sheet is reduced as the balancing item for the net change in cash from the cash flow statement.

c. Cash flow

Assuming lower production volumes decrease sales volume by 20 per cent in a mild scenario and 40 per cent in a severe scenario, while average selling prices increase by 31 per cent and 62 per cent respectively, revenues would be positively impacted by 5 per cent in the mild scenario and negatively impacted by 3 per cent in the severe scenario. Meanwhile, a prolonged period of extreme weather events could also encourage companies to make investments in mitigation and adaptation measures to make their production processes more resilient, which is not in scope of the analysis. For this scenario, projections made to the income statement and balance sheet subsequently flow into the cash flow statement and are captured accordingly.

SECTION 4

Potential credit risk impacts

An analysis was undertaken to gauge the impact of the two scenarios on a selection of 16 corporate companies across the three banks. Dynamic variables were adjusted within their financial statements as discussed in section 3.

In light of the different rating models of the three banks, the respective results were mapped to the S&P long run average corporate default rates 1981–2023 (S&P Global 2024) and the corresponding equivalent ratings as a result of the scenarios were compared to the baseline ratings.

Broadly, results showed that upstream producers, ie planters and millers, were more sensitive to the impact on palm oil prices and production cost in both scenarios. Integrated players, due to their diversified nature and financial heft, were less susceptible to the first-order impacts posed by nature risk. Companies with better financial strength were also more resilient to the short-term acute risks. Overall, the impact on companies was limited, especially for the mild scenario, although for certain companies in the severe scenario, the impact was elevated.

Table 7: Credit risk impacts for the mild scenario

Mild scenario						
Archetype	Geography	Count	Average notch change	# No notch change (Count)	1 notch downgrade	>1 notch downgrade (Count)
Planters and millers	Malaysia	5	-0.60	3	1	1
	Indonesia	8	-0.63	4	3	1
Integrated players	Indonesia	3	-0.33	2	1	0

Table 8: Credit risk impacts for the severe scenario

Severe scenario						
Archetype	Geography	Count	Average notch change	# No notch change (Count)	1 notch downgrade	>1 notch downgrade (Count)
Planters and millers	Malaysia	5	-1.60	1	1	3
	Indonesia	8	-0.88	3	3	2
Integrated players	Indonesia	3	-0.33	2	1	0

SECTION 5

Limitations and assumptions

Due to its exploratory nature, this analysis is subject to significant limitations and assumptions, notably at the scenario construction and financial analysis stages. Hence, the interpretation of the results from the credit risk analysis should take into account the constraints listed below.

5.1 Scenario construction

- In the absence of baseline supply volume data of selected companies, demand volume is assumed to equate to production yield.
- We assumed no second and/or third order effect on cost and price for millers and refiners.
- A straightforward approach is used to estimate corresponding price increases, without factoring broader market dynamics.
- In the construction of the scenario, we looked at country-level empirical data from Indonesia and Malaysia. Given the nascency of the topic and emerging understanding of nature risk, it is useful to acknowledge that data limitations exist, for example the granularity of the company-level and location (site)-specific data.
- While this study explores the interconnectedness of climate and nature risks, it does not fully account for the interactions between and within the two, such as increase in pathogens as a result of changes in temperature and humidity.

- The scenario envisages a one-year short-term acute impact, during which strategic management actions are not initiated. In practice, we note that management teams of corporates may well begin putting strategic mitigating actions in place, but quantifying the effects of those actions is outside the scope of this project.
- We also note that the El Niño and the ecosystem degradation effects may last for longer than one year. There may be price implications and therefore delayed financial impacts in the following and subsequent years.
- Transportation and maintenance costs remained constant. Decreased revenue in a severe scenario from lower production may impair asset values, especially plantations whose output potential is compromised. These factors could lead to asset write-downs and lower equity values. For companies with significant debt, this could increase leverage ratios to the point where creditworthiness becomes strained. This is not explored in the study.
- While downstream players such as retailers are not included in the study due to practicality and scope, they could be impacted by this nature loss scenario, and this would be an opportunity for future research in this area.

5.2 Financial analysis

- Given data limitations and the objectives of the exercise, the study was undertaken on a limited set of 16 samples, thus, the outcome does not represent a portfolio/industry-wide view.
- Impact on tree mortality caused by an intensified ENSO cycle and other nature risks such as forest fires are not considered. Previous research has found that El Niño alone did not significantly impact tree mortality, albeit in the Amazon region. For example, during the drought year in 1997, annual mortality rose to 1.91 per cent but quickly dropped back to 1.23 per cent in the year following El Niño (Williamson et al. 2000).
- We are not considering the mitigation and adaptation investments that the palm oil companies have actively put in place in recent years, such as planting climate-resilient varieties, implementing water, soil and pesticide management, and using palm processing waste as fertiliser (Roundtable on Sustainable Palm Oil 2022; Abubakar, Ishak, and Makmom 2021)

SECTION 6

Reflections

The main objective of this project is to build up internal capabilities through :

(i) Enabling the banks to recognise and evaluate nature-related dependencies and potential financial impacts in their wholesale lending portfolios.

(ii) Collectively developing an exploratory sector-specific scenario use case, which will signal to the broader region the potential business impacts that may be associated with nature loss and ensuing risks to the financial institutions that support them.

The exploratory approach taken provides an early indication of the direction of travel, with further areas to be studied:

- While we recognise that empirical studies for the palm oil industry are comparatively mature, this study highlights knowledge gaps before a more thorough real-world analysis can be conducted in routine risk analyses.
- This study focuses on the nature dependencies of the CPO companies, and as a progressive next step, the nature impacts (ie footprint) of CPO companies will need to be assessed.
- The transmission mechanism is complex. In order to complete this exploratory use case, most variables were kept constant. These assumptions should be taken into consideration and tested for future work.
- Given the niche and context specificity of nature risks such as geography and locale, scalability of the transmission mechanisms across sectors, geographies and value chains is not easily surmountable.
- While this study explores the interconnectedness of climate and nature risks, it does not fully account for the interactions between and within the two.
- The learnings from this project could be extended to other relevant industries that may also face nature risks, such as mining, renewables and real estate.

Through the creation of this use case, financial institutions increased engagement within their organisations on the risks arising from nature loss. The study evidenced the potential credit risk implications for climate–nature loss scenarios on the palm oil sector in Indonesia and Malaysia.

> While this study highlights significant knowledge gaps, the industry needs to continue to advance its understanding in this area. Collective efforts from all parties in the ecosystem, including financial institutions, real economy players and policymakers, will be needed to create positive change.

Appendix

Background research

Table 9: Evidence of impact on CPO production estimates in Malaysia and Indonesia, (relevant historical empirical data)

S/N	Author/Year	Study title	Scope	Demonstrated impact on CPO and FFB yields[2]
Evidence of impact from El Niño				
1	MPOB (Malaysian Palm Oil Board) 2012 cited in Rahman et al. 2013	The Impact of La Niña and El Niño Events on Crude Palm Oil Prices: An Econometric Analysis	1997/98 El Niño (very strong) [Malaysia] 2010 El Niño (strong) [Malaysia]	**-7.99%** volume YoY (1997/98) **-3.08%** volume YoY (2010)
2	UOBKH 2017 cited in Amirul et al. 2016	Impact of El Niño on Palm Oil Production	1997/98 El Niño (very strong) [Malaysia] 2015/16 El Niño (very strong) [Malaysia]	**-8.3%** volume YoY (1997/98) **-13.2%** volume YoY (2015/2016)
3	MPOB (Malaysian Palm Oil Board) 2017 cited in Amirul et al. 2016	Malaysian Palm Oil Board Palm Oil Statistics. Date accessed: 13 Jan 2017	2015/16 El Niño (very strong) [Malaysia]	**-13.2%** volume YoY
4	US Department of Agriculture cited in S&P Global 2023	Commodities 2024: Palm oil sees global recovery on biodiesel demand, stagnant supplies	2015/2016 El Niño (very strong)	**-9% (Mt/ha)** fruit volume YoY [Malaysia] **-17% (Mt/ha)** fruit volume YoY [Indonesia]
5	Koh 2024, Agricensus citing data from Wilmar International	El Niño takes a bite out of Indonesia palm giants' production	2023/24 El Niño (strong), Singapore based Wilmar International [Indonesia]	**-6%** FFB yields YoY
6	US Climate Prediction Center (CPC)	El Nino poses risk to 2024 palm output in Indonesia, Malaysia	2023/24 El Niño (strong) [Indonesia]	**-5%** to **-10%** oil palm yields YoY

2 Fresh fruit bunches (FFB) are harvested from oil palm trees and are the raw material used to produce crude palm oil (CPO). Approximately 24 per cent of the weight of FFB is converted into CPO. This means that any percentage loss in FFB yield directly results in an equivalent percentage loss in CPO yield, assuming the oil content remains constant.

7	American Economic Review	The Enduring Impact of the American Dust Bowl: Short- and Long-Run Adjustments to Environmental Catastrophe	Impacts of severe drought on yields over recent decades [USA]	**-20%** to **-40%** yields, volume YoY
8	US Department of Agriculture 2015	Commodity Intelligence Report – Indonesia: Palm Oil Production Prospects Dampened by El Niño Drought	1997/98 El Niño (strong) [Indonesia]	**-20%** to **-30%** oil palm yields
Evidence of impact from ecosystem degradation				
1	Forest Pathology 2014 https://doi.org/10.1111/efp.12140	Management of basidiomycete root- and stem-rot diseases in palm oil, rubber and tropical hardwood plantation crops	Average tree mortality rate from Basal Stem Rot [Malaysia]	**-3.7%** to **-10%** palm oil trees
2	Gintoron et al. 2023 https://doi.org/10.3390/insects14050454	Factors Affecting Pollination and Pollinators in Oil Palm Plantations: A Review with an Emphasis on the Elaeidobius kamerunicus Weevil	Decline in fruit set due to reduced pollinators [Malaysia]	**-4%** fresh fruit bunch yield YoY
3	Woittiez et al. 2017 https://doi.org/10.1016/j.eja.2016.11.002	Yield gaps in oil palm: A quantitative review of contributing factors [Global]	**Disease** – Ganoderma is potentially severe in Malaysia and Sumatra with up to 80% mortality at >15 YAP (Years after planting)	**-30%** to **-40%** at adolescent and >50% at mature palm oil trees in affected areas
			Water logging (Water-limited yield)	**-20%** to **-30%** in poorly drained mature plantations
			Topography and slope (Water-limited yield)	**-10%** to **-30%** yield reduction on slopes of 2–7° without conservation measures
4	Oldfield et al. 2019 https://doi.org/10.5194/soil-5-15-2019	Global meta-analysis of the relationship between soil organic matter and crop yields [Global]	Benefits of healthy soils for wheat and maize	**+20%** yield for wheat and **+10%** for maize when farming on healthy soils

Table 10: Estimated forecasts of future impact on CPO production estimates in Indonesia and Malaysia, by nature stress factor

S/N	Author/Year	Study title	Scope	Estimated impact on CPO
Forecasted impact of El Niño				
1	Rahman et al. 2013	The Impact of La Niña and El Niño Events on Crude Palm Oil Prices: An Econometric Analysis	Niño and La Niña [Malaysia]	**-3.37%** volume YoY
2	Various studies cited in Najihah et al. 2019	Effects of water stress on the growth, physiology and biochemical properties of oil palm seedlings	Global climate change, mixed geographies	**-30%** yield YoY
3	Sakar et al. 2019	Impacts of climate change on oil palm production in Malaysia	Global climate change [Malaysia] Temperature rise 1, 2, 3, 4°C, Sea level rise (SLR) 0.5, 1, 2m	**-10%** to **-41%** yield YoY (temp) **-2%, -4%, -8%** yield YoY (SLR)
4	MNRE (Ministry of Natural Resources and Environment) 2010 cited in Sakar et al. 2019	Malaysia's second National Communication (NC2) submitted to the United Nations Framework Convention on Climate Change (UNFCCC)	Temperature rise 2°C and rainfall decrease 10% [Malaysia]	**-30%** yield YoY
5	GAPKI/IPOA (Indonesian Palm Oil Association) 2023	Impacts of climate change on oil palm production in Malaysia	2023/24 El Niño (very strong) [Indonesia]	**+5%** yield YoY

Table 11: Impact of El Niño on CPO price (historical and forecast)

S/N	Author/Year	Study title	Scope	Year-on-Year change (%)
Historical impact of El Niño on CPO price				
1	Azlan et al. 2016, with data from Ng 2016	Impact of El Nino on Palm Oil Production, The Planter, Kuala Lumpur, Vol. 92 No. 1088	1982/83 El Niño (strong)	**+12.8%**
			1997/98 El Niño (strong)	**+22.5%**
2	BMI, 2023	El Nino poses risk to 2024 palm output in Indonesia, Malaysia	2023/2024 El Niño (strong) [Malaysia]	**+13%** – from MYR 3,551 to MYR 4,000 per tonne
3	Asia Palm Oil 2023	El Niño Expected to Have Minimal Impact on Palm Oil Production	2015/16 El Niño [Malaysia]	**+46%**
Forecasted impact of El Niño on CPO price				
4	Andri 2023, PwC	Commodity trading: CPO price projections, ready to heat up in the rest of the year?	2023/24 El Niño (strong) [Malaysia]	**+10%** to **+20%** from US$ 855/Mt
5	Azlan et al. 2016, with data from Voon and Sarah 2016	Impact of El Niño on Palm Oil Production, The Planter, Kuala Lumpur, Vol. 92 No. 1088	2015/16 El Niño [Malaysia]	**MYR 2,200–** **MYR 3,200**
6	Rahman et al. 2013, Malaysian Palm Oil Board	The Impact of La Niña and El Niño Events on Crude Palm Oil Prices: An Econometric Analysis	2013 El Niño [Malaysia]	**+3.6%** (increase from MYR 2,345 to MYR 2,431)

Glossary

Credit risk	The probability of a financial loss resulting from a borrower's failure to repay a loan.
Crude palm oil (CPO)	Oil extracted from the flesh of the palm fruit (the mesocarp).
Dependencies (on nature)	Dependencies are aspects of environmental assets and ecosystem services that a person or an organization relies on to function. A company's business model, for example, may be dependent on the ecosystem services of water flow, water quality regulation and the regulation of hazards like fires and floods; provision of suitable habitat for pollinators, who in turn provide a service directly to economies; and carbon sequestration. Taskforce on Nature-related Financial Disclosures (2025) Glossary
Downgrade	A negative change in the rating of a financial company's expected performance.
Dynamic variables	Variables whose values can change within the analysis.
Ecosystem services	The contributions of ecosystems to the benefits that are used in economic and other human activity. United Nations System of Environmental Economic Accounting (2023) Glossary
Global climate regulation services	Global climate regulation services are the ecosystem contributions to the regulation of the chemical composition of the atmosphere and oceans that affect global climate through the accumulation and retention of carbon and other GHG (e.g., methane) in ecosystems and the ability of ecosystems to remove (sequester) carbon from the atmosphere. ENCORE (2024) Ecosystem Services
Integrated players (palm oil)	A company that covers the entire palm oil value chain, from planting and harvesting oil palm trees to processing and refining the oil, often including mills and refineries.
Materiality ratings	Scale to provide users with an indication of the significance of the potential nature-related dependencies and pressures identified for given economic activities. ENCORE (2024) Materiality Ratings

Nature loss	The loss and/or decline of the state of nature. This includes, but is not limited to, the reduction of any aspect of biological diversity e.g., diversity at the genetic, species and ecosystem levels in a particular area through death (including extinction), destruction or manual removal, Taskforce on Nature-related Financial Disclosures (2025) Glossary
Nature-related risk	Potential threats (effects of uncertainty) posed to an organisation that arise from its and wider society's dependencies and impacts on nature. Taskforce on Nature-related Financial Disclosures (2025) Glossary
Pollination services	The ecosystem contributions by wild pollinators to the fertilization of crops that maintains or increases the abundance and/or diversity of other species that economic units use or enjoy. ENCORE (2024) Ecosystem Services
Provisioning services	Provisioning services are those ecosystem services representing the contributions to the benefits that are extracted or harvested from ecosystems. ENCORE (2024) Explore
Regulating services	Ecosystem services resulting from the ability of ecosystems to regulate biological processes and to influence climate, hydrological and biochemical cycles, and thereby maintain environmental conditions beneficial to individuals and society. ENCORE (2024) Explore
Scenarios	A scenario is a logically consistent story that describes a plausible future. It identifies some significant events, the main actors and their motivations, and how the world functions in this plausible future. It is intended to challenge thinking about what the future might be like and how they might respond under circumstances different from those they face today. Taskforce on Nature-related Financial Disclosures (2025) Glossary

Soil and sediment retention services	Soil erosion control services are the ecosystem contributions, particularly the stabilising effects of vegetation, that reduce the loss of soil (and sediment) and support use of the environment (e.g., agricultural activity, water supply). This may be recorded as a final or intermediate service. Landslide mitigation services are the ecosystem contributions, particularly the stabilising effects of vegetation, that mitigates or prevents potential damage to human health and safety and damaging effects to buildings and infrastructure that arise from the mass movement (wasting) of soil, rock and snow. This is a final ecosystem service. ENCORE (2024) Ecosystem Services
Soil quality regulation	The ecosystem contributions to the decomposition of organic and inorganic materials and to the fertility and characteristics of soils, e.g., for input to biomass production. ENCORE (2024) Ecosystem Services
Static variables	Variables with fixed values within the analysis.
Value chain	The full range of interactions, resources and relationships related to a reporting entity's business model and the external environment in which it operates. A value chain encompasses the interactions, resources and relationships an entity uses and depends on to create its products or services from conception to delivery, consumption and end-of-life, including interactions, resources and relationships in the entity's operations, such as human resources; those along its supply, marketing and distribution channels, such as materials and service sourcing, and product and service sale and delivery; and the financing, geographical, geopolitical and regulatory environments in which the entity operates. International Financial Reporting Standard (2023) S1 General Requirements for Disclosure of Sustainability-related Financial Information
Water purification services	Water purification services are the ecosystem contributions to the restoration and maintenance of the chemical condition of surface water and groundwater bodies through the breakdown or removal of nutrients and other pollutants by ecosystem components that mitigate the harmful effects of the pollutants on human use or health. ENCORE (2024) Ecosystem Services

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