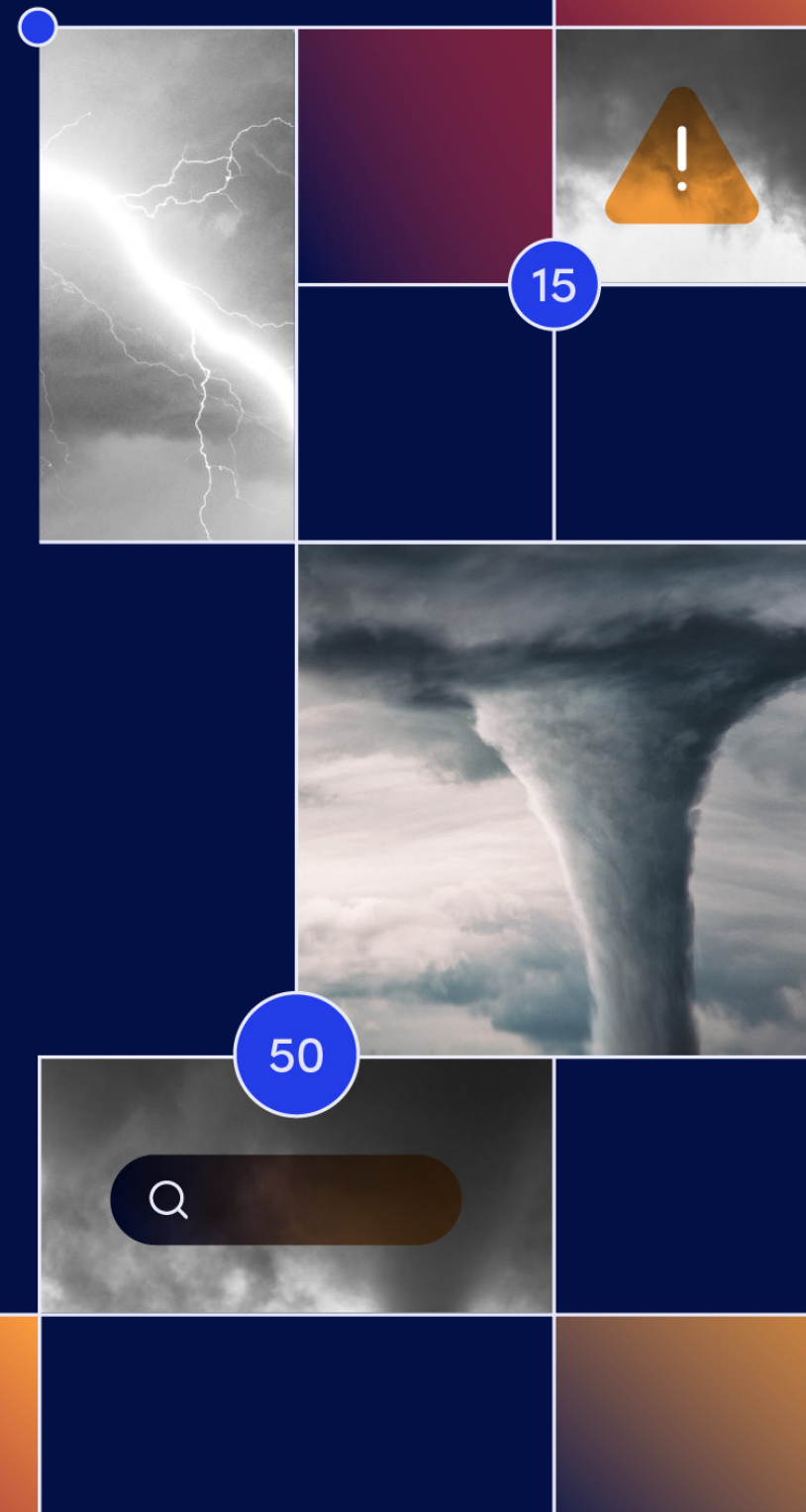


# Eye of the Storm

Natural Hazard Risk at Global Supply Hubs  
and Strategies for Resilience

Andrea Little Limbago, Ph.D.

Julia Hazel, Ph.D.



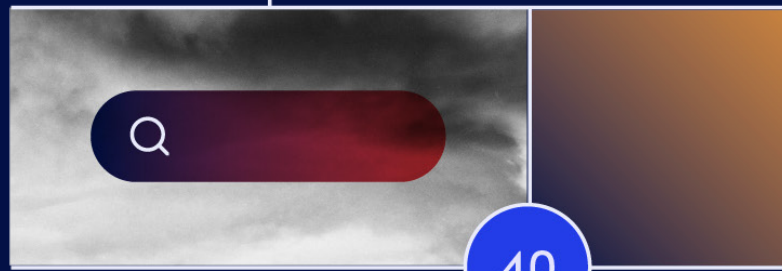
# Table of Contents

Overview	3
The Growing Cost of Natural Hazards on Supply Chains	3
10 Global Supply Chain Hubs at Risk	4
1. Colón, Panama	5
2. Dubai, United Arab Emirates (UAE)	6
3. Gujarat, India	7
4. Jakarta, Indonesia	8
5. Los Angeles, CA, USA	9
6. Port Hedland, Australia	10
7. Rotterdam, Netherlands	11
8. Santos, Brazil	12
9. Shanghai, China	13
10. Taiwan	14
Recommendations: Building Natural Hazard Resilience into Supply Chain Strategy	15
About Interos	17

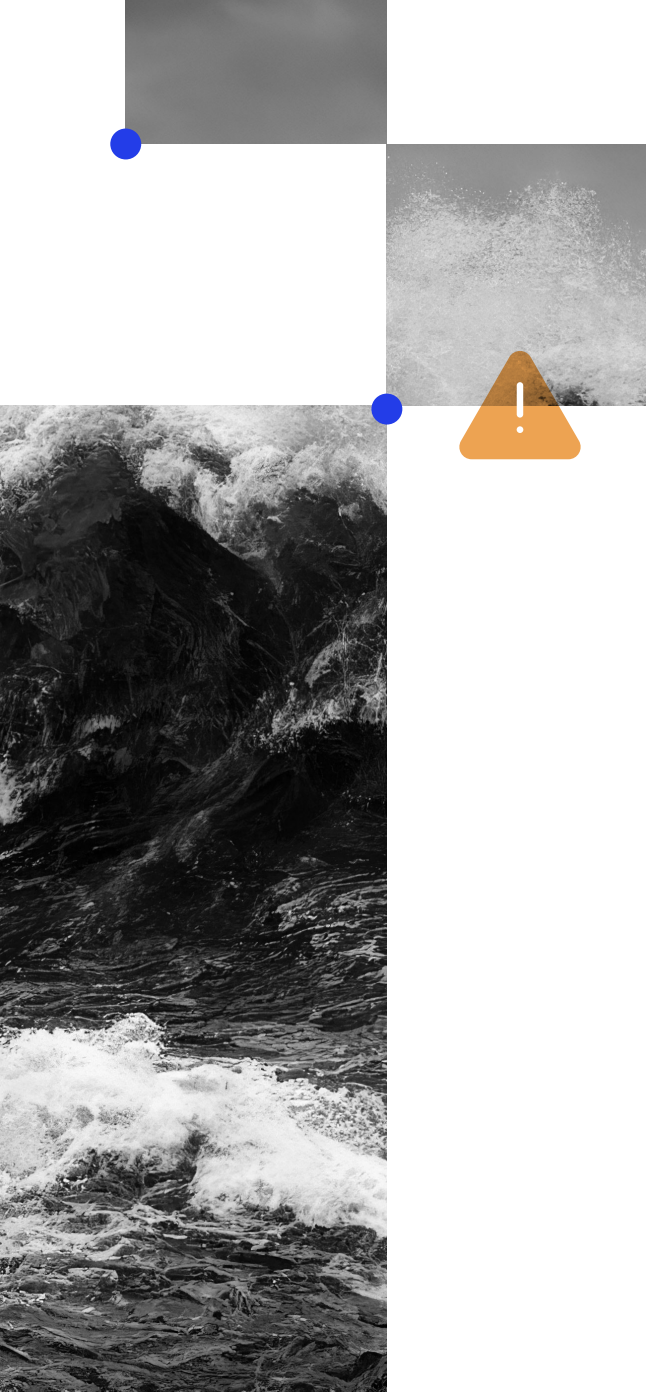
12



12



40



## Overview

Extreme weather has been inescapable, underscoring an alarming trend of escalating natural hazard-related shocks. The world saw its highest ever temperature in June 2023, a rare hurricane **drenched the Western U.S.**, **historic floods killed thousands in Libya**, and wildfires devastated Hawaii, claiming over 115 lives and causing **an estimated \$6 billion** in economic losses. Ports, railroads, and vital infrastructure are caught in the middle – with severe impacts to supply chain and industry. As of September 2023, cargo ships are restricted in the Panama Canal due to drought-induced low water levels. These are not isolated events, but growing phenomena across global supply chains.

The risk stemming from these and other natural hazards is not uniform, with stark differences geographically and over time. While some industries or commodities may be at greater risk due to this variation, all businesses are at risk whether they like it or not.

This whitepaper details specific natural hazard risks to 10 of the most important supply chain hubs across the globe. Disruptions at these areas ripple across global supply chains, impacting companies and communities that may not even be aware of their dependency. Companies that better identify and address diverse natural hazard risks while embracing climate adaptation strategies will be more resilient in this new normal of natural hazards.

## The Growing Cost of Natural Hazards on Supply Chains

In the U.S. alone, natural hazards caused \$145 billion in damages in 2021. In 2022, there were 42 weather disasters exceeding a billion dollars each in damages, **for a total of \$360 billion in losses**. According to one **study**, adverse weather variation impacts profitability in at least 70% of businesses. Despite these growing risks, and **warnings** from global policy makers, businesses are **slow** to respond.

This led us to ask: what might the natural hazard risk at global supply chain hubs look like? How do the risks differ by location and what industries might be affected? Below we analyze 10 cities that serve as key supply chain hubs and quantify their risk to a range of natural hazards. It's not a question of **if** these hubs may get affected by a natural hazard event but **when**. Companies would benefit from proactively integrating natural hazards risk and climate adaptation into their operational resilience strategies.



## 10 Global Supply Chain Hubs at Risk



The 10 supply chain hubs analyzed were selected to provide a globally diverse sample across relevant industries. These include sites that are critical for logistics, manufacturing and/or financial services. In each case, we focus solely on an assessed inherent natural hazard risk at each location.

The data was compiled using Interos' new Catastrophic Risk technology. It includes data on a variety of natural hazards, including volcanoes, wildfires and landslides. It also reflects climate change intensification – locations that are experiencing spikes in natural hazards and sea-level-rise forecasts.

The graphics beside each supply chain hub show how its geospatial location contributes to the natural hazard risk assessment. While these locations are all integral parts of global supply chains, their relative natural hazard risks vary, as do the industries or commodities which are most at risk of disruption.

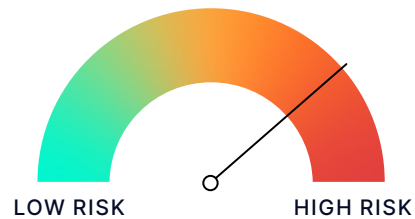


## 1. Colón, Panama

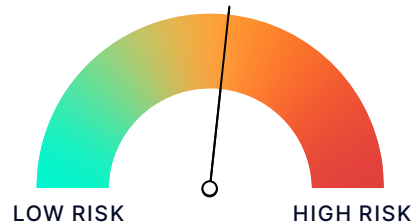
Located along the Caribbean coast and entrance to the Panama Canal, Colón sits along one of the world's most widely used maritime trade and shipping routes. Colón is the world's **second-largest** free trade zone and the largest in the Western Hemisphere, bringing in \$5 billion annually. The Colón Free Trade Zone also **accounts** for 8.5% of Panama's GDP and is critical for U.S.-based supply chains. Both the Canal and the port are strategically essential connectors between the hemispheres and are often the least expensive mode of transport between major global supply chain hubs.

### TOP NATURAL RISKS

#### Earthquake Risk



#### Sea-Level Rise Risk



Lowest Risk  
**JANUARY**



Highest Risk  
**JULY**

Colón is subject to natural disasters that disrupt Panama Canal traffic. In June 2023, the Panama Canal Authority **introduced** new water conservation efforts that restrict the number of daily transits due to extreme drought. Despite these restrictions, unprecedented drought **caused** over two-week delays in August 2023 that have continued in the following months.

The region has been in a drought for years, but this is not its only natural hazard risk. In 2019, a 6.2-magnitude earthquake **struck** near the Costa Rica-Panama border, one of many to shake the region in recent decades. The Pedro Miguel fault runs **through** the Panama Canal, posing a seismic risk to the entire area. Rising sea levels are also a concern that will increase in the years to come. This has already forced the residents of one Panamanian island to **relocate** to the mainland.

- **Highest Natural Hazard Risk:** Earthquakes and climate change intensification, with a specific risk of sea-level rise, as well as drought risk.
- **Lowest Natural Hazard Risk:** Cold weather severe storms.
- **Seasonality:** While one of the rainiest areas in the world, drought risk peaks in January and February, coinciding with the dry season. Warm weather severe storm risk peaks in the fall, introducing the potential for tropical cyclones. Extreme heat risks also peak late in the summer.

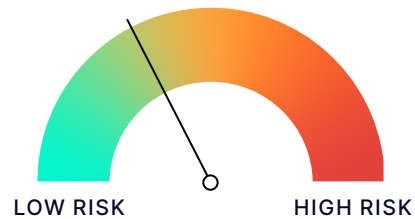


## 2. Dubai, United Arab Emirates (UAE)

Dubai boasts the 11th busiest port globally based on throughput and is strategically located near the Strait of Hormuz and the entrance to the Persian Gulf. Dubai also is a core maritime route for oil and gas, and a center for trillions of dollars of financial business and investment. Its largest trading partner is China, followed by India and the United States. The International Shipping Centre Development Index **named** Dubai the fifth most important shipping hub worldwide and the largest in the Middle East.

### TOP NATURAL RISKS

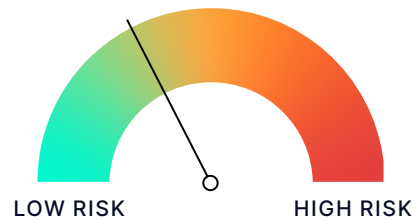
#### Sea-Level Rise Risk



The United Arab Emirates faces fewer natural hazard risks compared to many other supply chain hubs. The most prominent risk is extreme warm temperatures and **sandstorms**, the latter of which can ground flights and render air quality dangerously unhealthy.

- **Highest Natural Hazard Risk:** Extreme temperature risks and climate change intensification due to sea-level rise.
- **Lowest Natural Hazard Risk:** Warm and cold severe weather storms, wildfires, tectonic activity due to very low volcano risk.
- **Seasonality:** The heat risk spikes in the spring.

#### Heat Risk



Lowest Risk  
**MARCH**



Highest Risk  
**JANUARY**



### 3. Gujarat, India

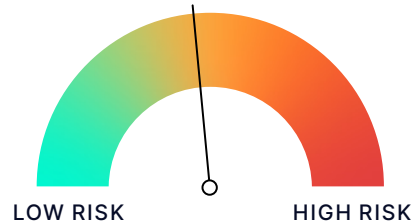
Home to **Mundra Port**, India's largest commercial port, Gujarat is known for everything from **red chillies** to raw materials to serving as the country's **newest** financial hub. Gujarat's **exports** doubled in 2022. According to the Director General of Foreign Trade, the highest valued exports included petroleum, diamonds, ceramics, cotton, machinery, and other engineering products.

Gujarat has experienced multiple natural hazard events in recent years. In June 2023, Biparjoy, a category 3 equivalent tropical cyclone, **caused** widespread damage and led to power outages, blocked roads, dozens of injuries, and the evacuation of 8,000 people. This event came as the state **reduced** its budget for natural disaster relief by 71% between 2022 and 2023.

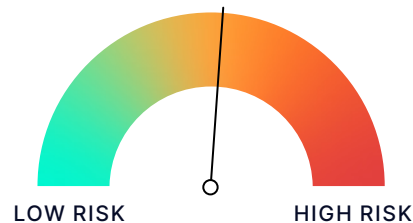
- **Highest Natural Hazard Risk:** With the longest coastline in India, coastal flood risk is a top hazard, as well as moderately high drought, extreme heat and tropical cyclones.
- **Lowest Natural Hazard Risk:** Wildfire risk, cold weather severe storm risk.
- **Seasonality:** There is a high tropical cyclone risk in the early summer, while drought peaks in the late fall.

#### TOP NATURAL RISKS

##### Heat Risk



##### Drought Risk



Lowest Risk

**MARCH**



Highest Risk

**SEPTEMBER**

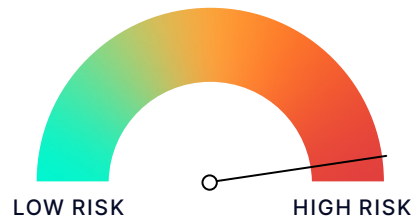


## 4. Jakarta, Indonesia

Indonesia **accounts** for almost half of global nickel production and one-fifth of global reserves. Nickel is a **critical mineral** used, among other things, for electric vehicle batteries. Indonesia is also a major player in bauxite, copper and tin. Jakarta, Indonesia's biggest city and one of the 10 **largest** mega-cities in the world, is home to Tanjung Priok, the country's largest and most active port. Indonesia is also the largest **exporter and producer** of palm oil, which is often **linked** to deforestation.

### TOP NATURAL RISKS

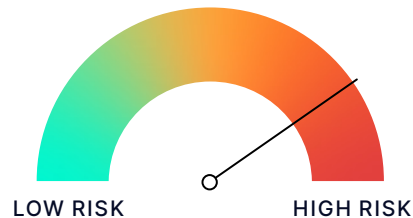
#### Tectonic Risk



LOW RISK

HIGH RISK

#### Flood Risk



LOW RISK

HIGH RISK



Lowest Risk

**JUNE**



Highest Risk

**SEPTEMBER**

Jakarta has been dubbed “the sinking megacity” due to rising sea levels and flood risk. In addition, a 5.6 magnitude earthquake **hit** 135 miles south of Jakarta in November 2022. Although the magnitude of this earthquake was not particularly high, its shallow depth led to a high shaking intensity and subsequent catastrophic damage. The impacts were especially severe given the densely populated area and weak infrastructure.

- **Highest Natural Hazard Risk:** Jakarta has a high tectonic risk, sitting at the convergence of the Australian Plate and Eurasian plate and numerous faults, including the Baribis Fault and recently discovered Kajai Fault. Sitting close to sea level and with 13 rivers that flow through the city, flood risk is extremely high in Jakarta. By one projection, the northern part of the city where the airport is located will be flooded by 2030.
- **Lowest Natural Hazard Risk:** Drought and cold weather severe storm risk.
- **Seasonality:** River flooding risk peaks at two distinct points during the fall and winter months.



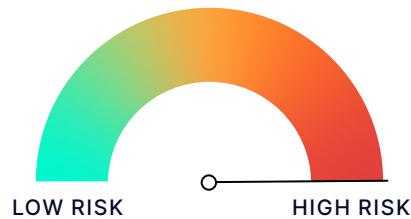
## 5. Los Angeles, CA, USA

The second-largest U.S. city is home to one of the country's busiest ports. With Los Angeles International Airport, as well as five other commercial airports in the metro area, LA is a prime location for airlift capacity. Coupled with extensive freeways and railroads, the city is an integral part of the global supply chain and logistics infrastructure. It is a major export center for animal feed, paper, soybeans, cotton and recycled materials, and a major import center for furniture, auto parts, apparel and plastics.

In recent years, extreme heat has caused evacuations and destruction in Los Angeles County. In 2022, extreme drought in the western U.S. reached its worst 22-year pattern in over **1,200 years**. The recent trends in both hotter and drier air are fueling ever-intensifying **wildfire activity**. In addition to extreme temperatures, LA County is also prone to earthquakes as it sits **atop** five fault lines, with additional faults that scientists have not yet discovered.

### TOP NATURAL RISKS

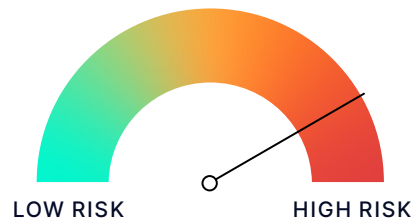
#### Earthquake Risk



LOW RISK

HIGH RISK

#### Wildfire Risk



LOW RISK

HIGH RISK



Lowest Risk

**DECEMBER**



Highest Risk

**SEPTEMBER**

- **Highest Natural Hazard Risk:** Tectonic activity due to extremely high earthquake and tsunami risk. Wildfire and drought risk are also top natural hazards.
- **Lowest Natural Hazard Risk:** Warm and cold weather severe storms, as well as extreme temperatures are much less likely.
- **Seasonality:** Drought risk peaks in the summer, while wildfire risk peaks in the fall.



## 6. Port Hedland, Australia

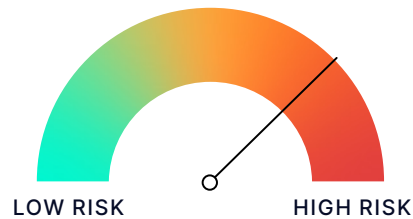
Port Hedland is the second-largest town in the Pilbara region, whose mining sector the OECD **describes** as “a global powerhouse in supply quality iron ore... and has considerable deposits of three of the eight key minerals required for battery manufacturing – lithium, manganese, and vanadium.”

Port Hedland is Australia’s **busiest** and largest shipping port, with half of the inner berthing areas operated by mining company BHP, underlining the area’s core role for critical minerals. It is prone to several natural hazards, notably tropical cyclones and wildfires. In April 2023, vessels in Port Hedland were **cleared** ahead of tropical cyclone Ilsa.

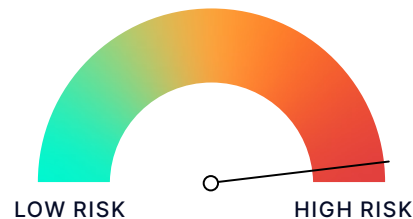
Bushfire season also poses a natural hazard risk. Over the past 50 years, the average temperature has risen **1° Celsius**, while the frequency of hot spells has become more frequent. Port Hedland is one of three Australian economic hubs **predicted** to be uninhabitable in the next 70 years due to rising temperatures.

### TOP NATURAL RISKS

#### Tropical Cyclone Risk



#### Wildfire Risk



Lowest Risk  
**JANUARY**



Highest Risk  
**MARCH**

- **Highest Natural Hazard Risk:** Extremely high wildfire risk due to bushfire propensity, high tropical cyclone risk, and moderate drought risk. The trend in wildfire frequency also shows an intensification over the past two decades.
- **Lowest Natural Hazard Risk:** Tectonic risks are low as well as flood risks from both river flooding and storm surge.
- **Seasonality:** Wildfire risk is highest during the (southern hemisphere) late spring and summer (October to March). Tropical cyclone risk is also high during the (southern hemisphere) summer and early fall (January to April).



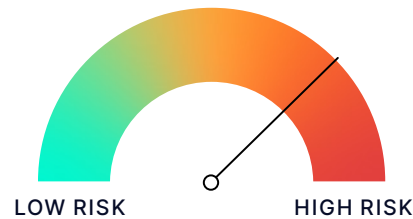
## 7. Rotterdam, Netherlands

An epicenter of European international trade, Rotterdam plays a significant role in delivering oil throughout the European Union. In addition to transporting crude and oil products, the Dutch port has directly added value of over €27 billion in recent years. But its real economic value is much larger. Rotterdam is also home to a flourishing IT and tech hub, with a large and growing tech startup ecosystem.

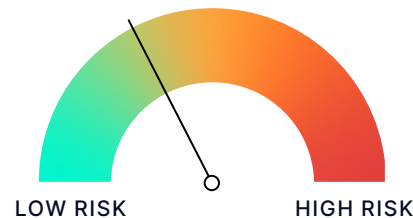
Rotterdam is situated at the delta of three rivers, and over 80% of its land is below sea level. As such, Rotterdam is regularly exposed to coastal floods and sea-level rise will continue to be a threat going forward. Since such a large portion of the city is below sea level, this **makes** water drainage difficult. While the city and port have made significant **investments** in flood protection, uncertainty around the extent of sea-level rise and flooding make it impossible to know whether these defenses will be sufficient.

### TOP NATURAL RISKS

#### Coastal Flood Risk



#### Sea-Level Rise Risk



Lowest Risk

**JUNE**



Highest Risk

**JANUARY**

- **Highest Natural Hazard Risks:** Flood risk (due to both coastal and river flooding), moderate tectonic risk due to high earthquake risk, and moderate climate change intensification risk primarily - due to sea level rise and recent drought intensification.
- **Lowest Natural Hazard Risks:** Warm weather severe storm risk, extreme temperature risk.
- **Seasonality:** River flooding risk peaks in winter months, drought intensification primarily occurs in late summer/fall months.



## 8. Santos, Brazil

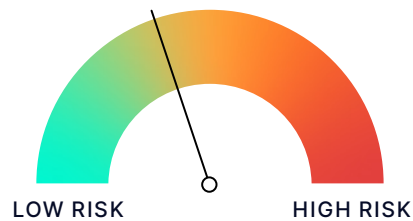
Latin America’s largest container port, Santos, is located 50 miles from Sao Paulo. It is the world’s **largest exporter** of sugar, orange juice, and coffee, and handles 54% of Brazil’s car exports, as well as machinery, electronics, and steel and ferroalloy products. Santos is strategically located near road and rail transport, and is **responsible** for 28% of Brazil’s foreign trade.

**Rain** is the major weather disruption in Santos. Nevertheless, an increase in drought conditions over the past few decades, as well as the **threat of sea-level rise**, pose a significant risk going forward. These are the largest natural hazards, but they are significantly less prominent than hazards in the other locations Interos analyzed.

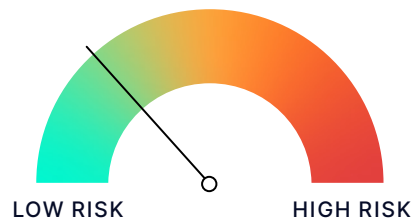
- **Highest Natural Hazard Risks:** Climate change intensification due to worsening drought and the threat of sea-level rise, as well as wildfire risk.
- **Lowest Natural Hazard Risks:** Cold weather severe storm risk and tectonic risk are virtually non-existent.
- **Seasonality:** Santos’ wildfire risk is highest at the beginning and end of the year, during its summer.

### TOP NATURAL RISKS

#### Climate Change Intensification



#### Wildfire Risk



Lowest Risk  
**AUGUST**



Highest Risk  
**MARCH**



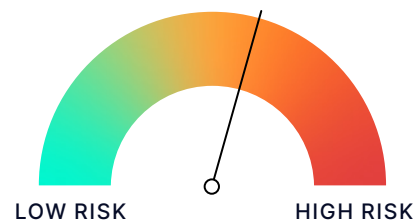
## 9. Shanghai, China

When Shanghai implemented a COVID-19 lockdown in 2022, it was yet another reminder of its core role in global supply chains. As a financial hub responsible for 20% of China's global trade, and also boasting the highest GDP of any Chinese city, Shanghai's closure sparked supply shortages and significant shifts in global supply chain routes – especially for the technology and electric vehicle sectors.

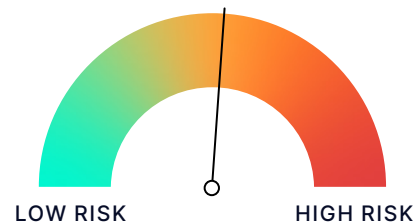
Shanghai faces significant natural hazards. By one **projection**, more than half of the city will be underwater at the end of the century due to flooding, earning it the dubious **distinction** of the world's most vulnerable city to flood risk. In September 2022, Shanghai's airports were **closed** in expectation of Typhoon Muifa, the **largest tropical cyclone** to hit the area in history. While Shanghai avoided major issues from back-to-back typhoons in August 2023, the wider region experienced record-breaking disruptions, including historic floods in **Beijing** and flooding and power outages in the **Philippines**.

### TOP NATURAL RISKS

#### Flood Risk



#### Sea Level Risk



- **Highest Natural Hazard Risks:** Flood risk due to potential for tidal and storm surge inundation, tropical cyclones, and the potential for river flooding. There is additional risk for climate change intensification, mainly due to sea-level rise.
- **Lowest Natural Hazard Risks:** Tectonic risk, drought risk, wildfire risk, cold weather severe storm risk.
- **Seasonality:** Warm weather severe storm risk peaks in summer due to potential for typhoons. Extreme warm temperature risk also peaks in summer.



Lowest Risk  
**DECEMBER**



Highest Risk  
**JULY**



## 10. Taiwan

The semiconductor manufacturing powerhouse Taiwan **produces** over 60% of the world’s semiconductors and 90% of the most advanced chips. Taiwan also plays a critical role in the global economy beyond semiconductors. It produces 70% of all functional textiles and is a **top 10 trade** partner for the U.S., with bilateral trade surpassing \$90 billion.

For decades, Taiwan’s dominance in the semiconductor industry has **earned it** the designation “Silicon Shield”, as a protective deterrent against Chinese aggression. While better known as a geopolitical fault line, Taiwan also sits along geological fault lines. The discovery of **three additional fault** lines in 2022 took the island’s total to 36 active fault lines — more than famously quake-prone San Francisco. The **topography** of Taiwan, with mountains and hills covering two-thirds of the territory, makes it prone to landslides, especially after heavy rain.

Aside from earthquakes and landslides, flooding is Taiwan’s greatest natural hazard risk. Floods are most common during typhoon season in the summer and fall months, and are exacerbated in the region due to the **overdevelopment** of urban areas. Taiwan is also particularly vulnerable to sea-level rise. A recent report suggested that by 2050, approximately three million people across Taiwan’s six largest cities would be either displaced by sea-level rise or vulnerable to storm surge.

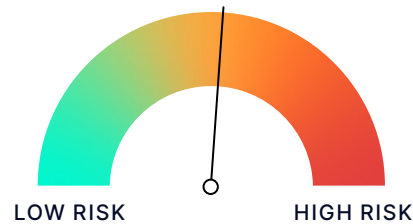
**Highest Natural Hazard Risks:** Tectonic risk due to propensity for earthquakes and tsunamis. Landslide risk is also moderately high.

**Lowest Natural Hazard Risks:** Wildfire risk, extreme temperature risk, winter storm risk.

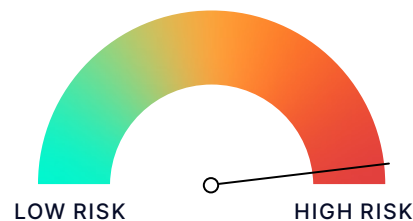
**Seasonality:** Cold weather severe storm risk peaks in August due to tropical cyclone activity. Climate change intensification also peaks at this time since there has been an increase in the frequency and magnitude of cyclones in recent decades.

### TOP NATURAL RISKS

#### Landslide Risk



#### Earthquake Risk



Lowest Risk

**DECEMBER**



Highest Risk

**JULY**

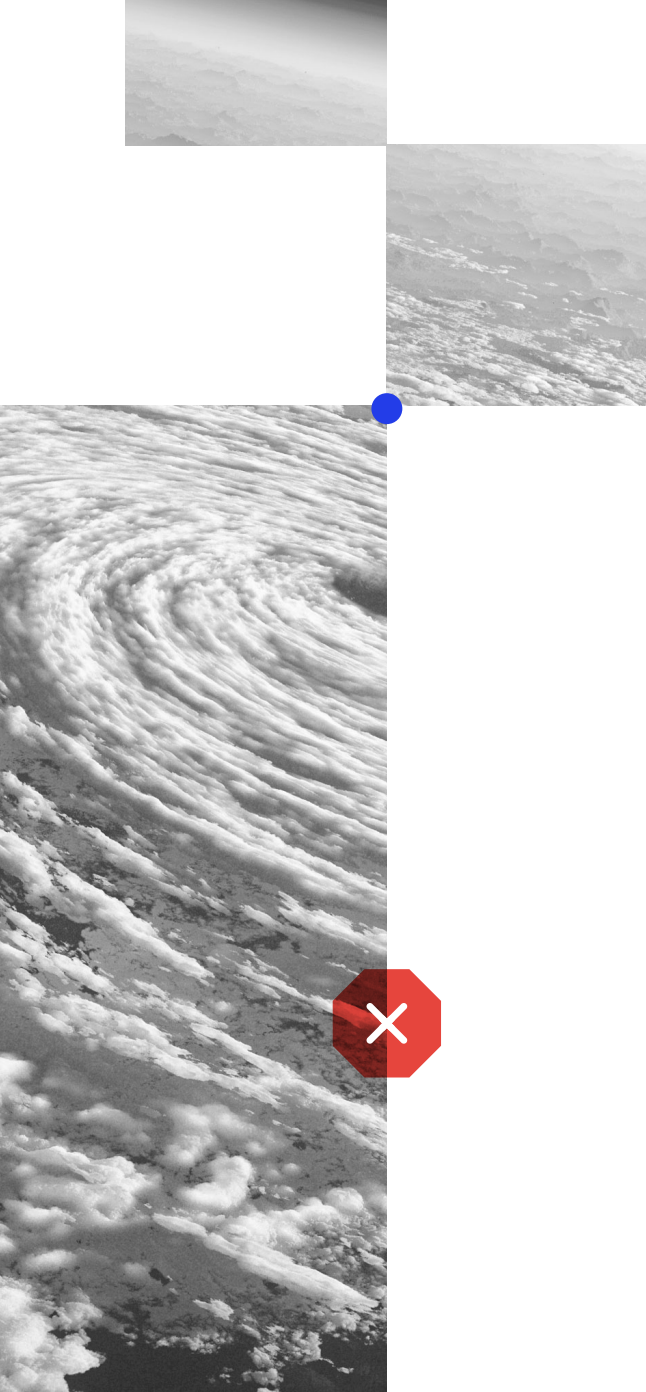


## Recommendations: Building Natural Hazard Resilience into Supply Chain Strategy

This analysis demonstrates the diversity of natural hazard risks to major global supply chain hubs. While beyond the scope of this whitepaper, the supporting infrastructure in each region has a profound effect on the ability to withstand a natural hazard. From **Rotterdam** to **Santos** to **Jakarta**, just as there is variation in the hazards, so too there is significant variation in the investment and innovation required at these hubs to address infrastructure vulnerabilities to catastrophic risk.

Similarly, there is tremendous **variation** in the investments and climate adjustment strategic planning of companies in light of these natural hazard risks. Climate adaptation – and a focus on addressing vulnerabilities and building resilience amid climate volatility – must become a top priority for organizations and communities that seek to thrive well into the future.

This entails adjusting to current or expected climate-induced environmental changes. This dynamic presents a growing market and investment opportunity, as those forward-leaning companies who adapt their supply chains now will be best equipped to handle the rapidly changing environment on the horizon.



Businesses and organizations engaged in global supply chain activity can take control of risk for competitive advantage. Already, leading enterprises are integrating natural hazards data as they proactively assess, monitor and respond to these risks. Three key principles underpin their actions:

1. **Proactive assessment and due diligence.** When assessing an existing supply chain, it's critical to identify which suppliers might be in areas more prone to natural hazards and proactively make adjustments to enable alternate suppliers. In addition, review the geographic diversification of the supply chain writ large to identify potential geographic concentration risks in disaster-prone areas. Finally, in new supplier assessments, integrate natural hazard risk as part of the evaluation process.
2. **Continuous monitoring.** To understand how a current natural hazard may impact your supply chain, map supply chains against these catastrophic hazards to surface unforeseen ways they may ripple throughout your extended global network. This can instigate continuation of operations and other mitigation plans to minimize the level of disruption.
3. **Rapid response.** When natural disaster or extreme weather strike, customer organizations need to be able to understand the potential impact quickly, so they can activate existing contingency and business continuity plans. Rapid response actions can include switching orders to backup suppliers or moving work to alternate locations in different geographic regions.

Visit [Interos.ai](https://www.interos.ai) to learn more about how your enterprise can understand the ripple effects of risk within interconnected supply chains and the necessary steps to prevent damage.



## About Interos

Interos is the AI-first operational resilience company – helping clients achieve Resilience by Design™. Our pioneering scoring and relationship discovery technologies enable customers to automate risk assessment, detection, and response. As the world’s first, and only, automated supplier resilience platform, we map and monitor physical and digital supply chains at scale to protect organizations from regulatory violations, unethical labor, cyber-attacks, bankruptcy, catastrophe, and other systemic vulnerabilities. Interos serves a variety of commercial, government, and public sector customers around the world including a host of Global Fortune 500 companies from within the members of the Five Eyes nations.

[Learn More](#)

Additional information:  
[www.interos.ai](http://www.interos.ai) or 1 (703) 745-5578

© Copyright 2023, Interos Inc. All rights reserved. Interos is a registered trademark. All other products are trademarks or registered trademarks of their respective owners.

091823

